This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

6398

No. —.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF PUBLICATIONS.

FARMERS' BULLETINS
Nos. 276–300,

WITH CONTENTS AND INDEX.

PREPARED UNDER THE SUPERVISION OF
GEO. WM. HILL,
EDITOR AND CHIEF.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1908.

S21
.A6
2d set

D. OF D.
JAN 9 1909

CONTENTS.

FARMERS' BULLETIN No. 276.—EXPERIMENT STATION WORK, XXXIX: Page.

Improvements in peach growing 5
Mulberries 6
Alfalfa culture in the Eastern United States 9
Oat culture in the South 14
Improvement of grass land 18
Succotash as a soiling crop 20
Tankage and bone meal for hogs 21
Grinding corn for hogs 25
Dips as lice killers 25
Digestibility of fish and poultry 26
Honey vinegar 28
Suggestions for the management of the farm woodlot 29

FARMERS' BULLETIN No. 277.—THE USE OF ALCOHOL AND GASOLINE IN FARM ENGINES:

Sources of power 5
Comparative cost of power from different sources 6
Comparative cost of energy in different fuels 7
Thermal efficiency 8
Adaptability of various types of engines 10
First use of alcohol engines 12
Elementary engine mechanism 15
Explosive mixtures 18
Liquid fuels 22
Heat of combustion 25
Air necessary for combustion 26
Vaporization of fuel 27
Effect of initial compression 37
Practical experience with alcohol engines in Germany 37
Conclusions 39

FARMERS' BULLETIN No. 278.—LEGUMINOUS CROPS FOR GREEN MANURING:

Green manuring 5
The use of green manures 6
The principal leguminous crops 7
How legumes get nitrogen from the air 8
Inoculation 9
Sources of soil nitrogen 10
Loss of soil nitrogen 11
Composition of green manure crops 11
Green manuring compared with feeding 12
Orchard cover crops 13
Crops to follow green manures 14
The choice of a green manure crop 14
The principal green manure crops 15

Page.

FARMERS' BULLETIN No. 279.—A METHOD OF ERADICATING JOHNSON GRASS:

Introduction 5
Rootstock habits of Johnson grass 6
Types of rootstock development 7
Method of eradication based on rootstock habits 10
Experimental results 12
Necessity of careful tillage 13
Chemical methods of destruction not practical 14
Rotation with winter grain 14
Rotation with cultivated crops 15
Cutting back sometimes necessary for eradication 16
Summary and conclusions 16

FARMERS' BULLETIN No. 280.—A PROFITABLE TENANT DAIRY FARM:

Introduction 7
Contract for the operation of this farm 7
Farm animals 8
Cropping system 9
Buildings 11
Hired help 14
Handling manure 14
Equipment 15
Disposal of product 15
Financial statement for 1905 16

FARMERS' BULLETIN No. 281.—EXPERIMENT STATION WORK, XL:

Insoluble phosphates 5
Forms and methods of applying lime 7
Fertilizing value of the sediment in irrigation water 8
Hardy Bermuda grass 10
The Williamson method of corn culture 13
Carbon bisulphid for killing sassafras sprouts 16
Soluble oils for the control of San Jose scale 17
Indian corn as a food for man 18
Storing preserves, canned fruits, and canned vegetables 22
Natural and artificial incubation of chickens 24
Bare-lot method of raising lambs to avoid nodule disease 28
Some milk terms 29

FARMERS' BULLETIN No. 282.—CELERY:

Introduction 7
Climatic and soil requirements of celery 9
Fertilizers 10
Preparation of the soil 11
Seed sewing and plant production 12
Transplanting 14
Watering 14
Planting in the open ground 17
Mulching 18
Cultivation 19
Diseases 21
Insect enemies and their control 22
Methods of blanching 23
Storing 28
Marketing 32
Profits to be derived from celery culture 34
Varieties of celery 36

Page.

FARMERS' BULLETIN No. 283.—SPRAYING FOR APPLE DISEASES AND THE CODLING MOTH IN THE OZARKS:

Introduction 5
Scope of the work 6
Orchard conditions in the Ozarks 6
Plan of work 7
Bitter-rot 7
Apple blotch 14
Leaf-spot diseases 18
Apple scab 20
The codling moth 23
Commercial results 32
Materials for spraying 34
Equipment for spraying 38
Applying the spray 40

FARMERS' BULLETIN No. 284.—INSECT AND FUNGOUS ENEMIES OF THE GRAPE EAST OF THE ROCKY MOUNTAINS:

Insect enemies 5
Insecticides 26
Fungous diseases 28
Fungicides 38
Spraying 41

FARMERS' BULLETIN No. 285.—THE ADVANTAGE OF PLANTING HEAVY COTTON SEED:

Heavy versus light seed 5
Preparation of seed for separation 6
Method of separating seed 9
Tests of separated seed 11
Separation of Sea Island cotton seed 14
How to obtain the necessary apparatus for cotton seed separation 16

FARMERS' BULLETIN No. 286.—COMPARATIVE VALUE OF WHOLE COTTON SEED AND COTTON-SEED MEAL IN FERTILIZING COTTON:

Introduction 5
Seed used for fertilizer 5
Attitude of the oil mills with reference to crushing the seed 6
Position of growers as to disposal of seed 6
Points considered in testing seed in comparison with meal 7
Character of land used for tests 7
Relative quantities of seed and meal tested 7
Lasting effect of seed 7
Relative availability of plant food in seed and meal 8
Conclusions drawn from results of experiments 12
Profit to growers by disposing of seed 12
Preservation of seed 13

FARMERS' BULLETIN No. 287.—POULTRY MANAGEMENT:

Making a start with poultry 5
Classification 5
Houses and inclosures 6
Management of hens for egg production 19
Raising chickens 27
Broilers, roasters, and capons 34
Fattening poultry 36
Marketing poultry and poultry products 38
Preserving eggs 41
Diseases, bad habits, and insect pests 42

Farmers' Bulletin No. 288.—The Nonsaccharine Sorghums:

Page.
Classification of sorghums 7
Introduction into the United States 7
Groups of nonsaccharine sorghums 8
Characteristics of the different varieties 9
Importance of the crop 11
Soils adapted to the crop 12
Drought resistance 12
Alkali resistance 13
Effect of sorghums on the land 13
Preparation of the soil 14
Planting 15
Cultivation 16
Harvesting 17
Thrashing 19
Yields 20
Utilization of the crop 21
Feeding value and chemical analyses 25
Market for the seed 26
Diseases and injurious insects 26
Improvement of the crop 27
Summary 28

Farmers' Bulletin No. 289.—Beans:

Introduction 5
Types of beans 6
Field and garden groups 7
Acreage grown 8
Field beans 10
Garden beans 18
Diseases and enemies 28

Farmers' Bulletin No. 290.—The Cotton Bollworm:

Introduction 7
Life cycle 8
Food plants 10
Seasonal history 11
Extent of injury 12
Means of control 14
Field work, 1905–1906 20
The more important natural factors in bollworm control 29
Recommendations 31

Farmers' Bulletin No. 291.—Evaporation of Apples:

Introduction 5
Types of evaporators 6
Evaporator appliances, etc 18
Apples suitable for evaporation 26
Preparing the fruit for drying 27
Drying the fruit 29
Handling the waste 32
Weight of evaporated apples 33
Laws relating to evaporated fruits 33
Handling evaporated apples 34
Range of prices 34
Grading 35

Farmers' Bulletin No. 291.—Evaporation of Apples—Continued. Page.

Kinds of packages used ... 35
Packing ... 36
Storing the fruit ... 38

Farmers' Bulletin No. 292.—Cost of Filling Silos:

Introduction ... 5
Methods employed ... 5
Arrangement of labor ... 9
Size of loads ... 10
Crops used ... 11
Condition of the crops when cut ... 11
Equipment ... 12
Partnership arrangement among farmers ... 15

Farmers' Bulletin No. 293.—Use of Fruit as Food:

Introduction ... 7
Wild and cultivated fruits ... 7
Market conditions and fruit supply ... 9
Color and flavor of fruits ... 10
Composition of fruits ... 11
Ripening and its effect on composition ... 20
Ways of serving fruit ... 21
Place of fruit in the diet ... 22
Digestibility of fruit ... 25
Relative economy of fruits and other foods ... 26
Cooking and its effects on fruit; jelly making ... 28
Overripe, decayed, and unripe fruit ... 30
Handling and marketing fruit ... 32
Storing fruit ... 34
The hygiene of fruit ... 35
Extent of the fruit industry in the United States ... 36
Conclusions ... 38

Farmers' Bulletin No. 294.—Farm Practice in the Columbia Basin Uplands:

Introduction ... 7
Description of the region ... 7
Soils ... 11
Agricultural history ... 11
Cropping systems ... 13
Soil tillage ... 13
Varieties of wheat grown ... 22
The permanency of the single-crop system of farming ... 27
Conclusions ... 29

Farmers' Bulletin No. 295.—Potatoes and Other Root Crops as Food:

Introduction ... 5
Potatoes ... 7
Cetewayo, or Zulu, potatoes ... 23
Sweet potatoes ... 23
The Jerusalem artichoke ... 28
Stachys ... 29
Tropical starch-bearing roots ... 29
Succulent roots, tubers, and bulbs ... 32
Roots used as condiments ... 41
Summary ... 42

FARMERS' BULLETIN NO. 296.—EXPERIMENT STATION WORK, XLI: Page.

Wells and a pure water supply 5
Availability of phosphates in relation to soil acidity 6
Pure seed versus poor seed 7
Selection for disease-resistant clover 9
Eradication of wild mustard 10
Sterilization of soils for the prevention of diseases of plants 11
Production of seedless tomatoes 13
Pickling olives and mock olives for home use 14
The hay box or fireless cooker 16
Combating insect enemies of shade trees 19
Feeding whole grain 21
The improvement of cattle 23
Ventilation of stables 25
Hog cots 27
Preserving eggs in water glass 29
American camembert cheese 31

FARMERS' BULLETIN NO. 297.—METHODS OF DESTROYING RATS:

Introduction 3
Methods of destroying rats 4
Rat-proof construction 7
Natural enemies of rats 8
Conclusions 8

FARMERS' BULLETIN NO. 298.—FOOD VALUE OF CORN AND CORN PRODUCTS:

Introduction 5
Food value of corn 8
Milling 11
Cooking 15
Hulled corn 21
Corn breakfast foods 21
Pop corn and parched corn 22
Digestibility of foods made from corn 23
Wholesomeness of corn 26
Raw corn as an article of diet 28
Place of corn in the diet 29
Pecuniary economy of corn 32
Green corn 34
Summary 37

FARMERS' BULLETIN NO. 299.—DIVERSIFIED FARMING UNDER THE PLANTATION SYSTEM:

Introduction 7
An experiment in diversified farming 9
Conclusion 14

FARMERS' BULLETIN NO. 300.—SOME IMPORTANT GRASSES AND FORAGE PLANTS FOR THE GULF COAST REGION:

Mexican clover 5
Beggarweed 7
Velvet beans 9
Guinea grass 11
Para grass 13

O

Issued March 11, 1907.

968

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 276.

Experiment Station Work,

XXXIX.

Compiled from the Publications of the Agricultural Experiment Stations.

IMPROVEMENTS IN PEACH GROWING.
MULBERRIES.
ALFALFA IN THE EASTERN STATES.
OAT CULTURE IN THE SOUTH.
IMPROVEMENT OF GRASS LAND.
SUCCOTASH AS A SOILING CROP.
TANKAGE AND BONE MEAL FOR HOGS.
GRINDING CORN FOR HOGS.
DIPS AS LICE KILLERS.
DIGESTIBILITY OF FISH AND POULTRY
HONEY VINEGAR.
THE FARM WOODLOT.

JANUARY, 1907.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.
A. C. TRUE, Director.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

THE AGRICULTURAL EXPERIMENT STATIONS.

Alabama—
  College Station: *Auburn;* J. F. Duggar.[a]
  Canebrake Station: *Uniontown;* J. M. Richeson.[b]
  Tuskegee Station: *Tuskegee;* G. W. Carver.[a]
Alaska—*Sitka:* C. C. Georgeson.[c]
Arizona—*Tucson:* R. H. Forbes.[a]
Arkansas—*Fayetteville:* W. G. Vincenheller.[a]
California—*Berkeley:* E. J. Wickson.[d]
Colorado—*Fort Collins:* L. G. Carpenter.[a]
Connecticut—
  State Station: *New Haven;* E. H. Jenkins.[a]
  Storrs Station: *Storrs;* L. A. Clinton.[a]
Delaware—*Newark:* Harry Hayward.[a]
Florida—*Gainesville:* P. H. Rolfs.[a]
Georgia—*Experiment:* Martin V. Calvin.[a]
Hawaii—
  Federal Station: *Honolulu;* J. G. Smith.[c]
  Sugar Planters' Station: *Honolulu;* C. F. Eckart.[a]
Idaho—*Moscow:* H. T. French.[a]
Illinois—*Urbana:* E. Davenport.[a]
Indiana—*Lafayette:* A. Goss.[a]
Iowa—*Ames:* C. F. Curtiss.[a]
Kansas—*Manhattan:* C. W. Burkett.[a]
Kentucky—*Lexington:* M. A. Scovell.[a]
Louisiana—
  State Station: *Baton Rouge.*
  Sugar Station: *Audubon Park, New Orleans.*
  North Louisiana Station: *Calhoun;* W. R. Dodson (*Baton Rouge*).[a]
Maine—*Orono:* C. D. Woods.[a]
Maryland—*College Park:* H. J. Patterson.[a]
Massachusetts—*Amherst:* W. P. Brooks.[a]
Michigan—*Agricultural College:* C. D. Smith.[a]
Minnesota—*St. Anthony Park, St. Paul:* W. M. Liggett.[a]
Mississippi—*Agricultural College:* W. L. Hutchinson.[a]
Missouri—
  College Station: *Columbia;* H. J. Waters.[a]
  Fruit Station: *Mountain Grove;* P. Evans.[a]
Montana—*Bozeman:* F. B. Linfield.[a]
Nebraska—*Lincoln:* E. A. Burnett.[a]
Nevada—*Reno:* J. E. Stubbs.[a]
New Hampshire—*Durham:* W. D. Gibbs.[a]
New Jersey—*New Brunswick:* E. B. Voorhees.[a]
New Mexico—*Agricultural College:* L. Foster.[a]
New York—
  State Station: *Geneva;* W. H. Jordan.[a]
  Cornell Station: *Ithaca;* L. H. Bailey.[a]
North Carolina—*Raleigh:* B. W. Kilgore.[a]
North Dakota—*Agricultural College:* J. H. Worst.[a]
Ohio—*Wooster:* C. E. Thorne.[a]
Oklahoma—*Stillwater:* W. L. English.[a]
Oregon—*Corvallis:* J. Withycombe.[a]
Pennsylvania—*State College:* T. F. Hunt.[a]
Porto Rico—*Mayaguez:* D. W. May.[c]
Rhode Island—*Kingston:* H. J. Wheeler.[a]
South Carolina—*Clemson College:* J. N. Harper.[a]
South Dakota—*Brookings:* J. W. Wilson.[a]
Tennessee—*Knoxville:* H. A. Morgan.[a]
Texas—*College Station:* J. W. Carson.[d]
Utah—*Logan:* P. A. Yoder.[a]
Vermont—*Burlington:* J. L. Hills.[a]
Virginia—*Blacksburg:* A. M. Soule.[a]
Washington—*Pullman:* E. A. Bryan.[a]
West Virginia—*Morgantown:* J. H. Stewart.[a]
Wisconsin—*Madison:* W. A. Henry.[a]
Wyoming—*Laramie:* B. C. Buffum.[a]

---

[a] Director. [b] Assistant director. [c] Special agent in charge. [d] Acting director.

EXPERIMENT STATION WORK.

Edited by W. H. BEAL and the Staff of the Experiment Station Record.

Experiment Station Work is a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. TRUE, Director, Office of Experiment Stations.

CONTENTS OF NO. XXXIX.

	Page.
Improvements in peach growing	5
Mulberries	6
Alfalfa culture in the eastern United States	9
Oat culture in the South	14
Improvement of grass land	18
Succotash as a soiling crop	20
Tankage and bone meal for hogs	21
Grinding corn for hogs	25
Dips as lice killers	25
Digestibility of fish and poultry	26
Honey vinegar	28
Suggestions for the management of the farm woodlot	29

ILLUSTRATIONS.

Page.
FIGS. 1 and 2. Groups of chestnut sprouts before and after thinning.......... 31, 32

EXPERIMENT STATION WORK.[a]

IMPROVEMENTS IN PEACH GROWING.[b]

In view of the rapid decline in the peach industry in New Jersey, as well as in Delaware and Maryland, in recent years, G. F. Warren, of the New Jersey Station, undertook a careful study of the factors contributing to this condition and the possible means of overcoming it.

According to the United States census reports, there were in the United States 53,886,000 peach trees in 1890, and 99,919,000 in 1900, showing an increase of over 85 per cent. During this time the number in New Jersey decreased from 4,414,000 in 1890 to 2,747,000 in 1900, a loss of 38 per cent. Only three States in the Union showed a decrease, New Jersey, Delaware, and Maryland; every other State increased its peach orchards. In 1890 these three States had 28 per cent of all the peach trees in the United States. In 1900 they had only 9 per cent. There has, in fact, been a panic among the growers.

The immediate cause of this condition has been the San José scale. But this has not been the only trouble. As is usual when any serious enemy threatens a crop, all troubles are charged to this pest. Damages from starvation, lack of tillage, borers, leaf-curl, and brown-rot are very frequently all bunched and charged to the account of the scale. * * *

In the fieldwork a study was made of soils, tillage, fertilization, spraying, varieties, diseases, insects, and other questions.

The more important suggestions to growers with a view to overcoming present unfavorable conditions are thus summarized:

First year.—Select a well-drained field, one that also has good air drainage, higher than the surrounding land if possible.

If possible have the field some distance from other orchards.

Lime the soil before planting, unless sure that it is not needed.

Buy good thrifty trees of a nurseryman who is not only honest, but intelligent—one who knows the diseases of the peach, so that he will not be propagating diseased trees.

Remove the borers, if there are any.

Prune to a whip, or nearly so.

Dip in lime, sulphur, and salt before setting.

Plant far enough apart so that it will be easy to drive through when spraying.

Fertilize well and plant corn or other tilled crops between the trees.

Prune in June, so as to start the formation of the heads.

Remove the borers in the fall.

Spray the next spring.

Subsequent years.—Prune every year, doing some heading-in as well as thinning out.

Spray thoroughly every spring before the buds swell.

Till every year, beginning early in the season and stopping early.

Fertilize liberally with phosphoric acid and potash, particularly with potash. If barnyard manure is used, also apply muriate of potash.

Remove the borers every fall and again in the spring.

After having given this good care, promptly remove all sick trees.

---

[a] A progress record of experimental inquiries, published without assumption of responsibility by the Department for the correctness of the facts and conclusions reported by the stations.

[b] Compiled from New Jersey Stas. Bul. 197.

Thin the fruit when necessary.

Grade the fruit carefully. Put up the first quality in a package that differs from that used for the poorer grades.

If the peach orchard is neglected in order to care for the corn crop, the profits must be expected to come from the corn.

MULBERRIES.[a]

The mulberry is but little cultivated as a fruit in America. There is very little market demand for it and as a home table fruit it is sweetish and considered rather insipid, though some enjoy it as a fresh dessert fruit. It has, however, several valuable features which, according to a recent bulletin by H. H. Hume and F. C. Reimer, of the North Carolina Station, makes it worthy of more extended culture in the home grounds than is at present given to it.

To begin with, the fruit will grow successfully on nearly any kind of soil, doing best probably on moist sandy loams. The tree is a rapid, vigorous grower, requires practically no culture, makes an ornamental shade tree, and some of the better varieties will yield from 10 to 12 bushels of fruit per season. A valuable feature of the fruit is that it ripens almost continuously over a period of two to four months every year. The fruit is greatly relished by hogs and poultry. Birds prefer it to cherries or strawberries, and when planted in the vicinity of these fruits it serves as a protection to them.

From the standpoint of fruit production the North Carolina Station recommends the following varieties for planting about the farm: New American, Black English, Stubbs, and Townsend of the black-fruited varieties; and White English and White Russian of the white-fruited sorts. Of the New American, Professor Bailey, in an early bulletin of the Cornell Station, states that it is the best sort known for the Northern States. The tree is a hardy, vigorous grower, productive, and bears continuously from late June until September. Large trees will produce 10 bushels of fruit in a season. The fruit varies in length from 1 to 2 inches and is a glossy black when ripe. It is frequently sold for the Downing, but is superior to that variety.

The Black English is considered by Hume and Reimer as one of the most satisfactory varieties for planting in North Carolina. The tree is a strong upright grower, and bears a large amount of fruit of medium size from May to July. The flavor is sweetish and the quality only fair. The Townsend is considered by the same authors as the earliest fruiting variety now grown, ripening in Florida from the latter part of March through April. The trees are very prolific, fruiting abundantly in the nursery row one year from grafting. It is of medium size, 1 by ½ inch, black, with a sweetish flavor not differing from other mulberries.

---

[a] Compiled from New York Cornell Sta. Bul. 46; North Carolina Sta. Bul. 194.

The Stubbs is a wide-spreading, vigorous, prolific variety. The fruit is very large, varying from 1½ to 2 inches in length and from ½ to ⅝ inch in diameter, with a bright deep red color, becoming black, subacid, and of excellent quality. The ripening season in North Carolina is from June to August.

Of the white-fruited varieties recommended by the North Carolina Station, White English is considered by far the best. It is a heavy bearer, producing sweet, medium-sized fruits of good quality from May to July. The White Russian seems to be a small, bushy, very hardy sort, and quite productive. The fruit is of medium size, white, very sweet, and of fair quality. The season is from May to June.

In addition to the use of mulberries as a fruit, the leaves constitute the chief food of the silkworm. In the West and Northwest also the Russian mulberry (*Morus alba* var. *tartarica*) has proved excellently adapted for planting in shelter belts and hedges and also for fence posts and fuel. This variety is very hardy against both cold and drought and makes a splendid growth there. It is the species commonly used there as a stock on which to propagate the more fruitful varieties. The Russian mulberry possesses particular merit as a hedge plant in cold regions from an ornamental standpoint. There is also a number of ornamental forms of the mulberry, including weeping sorts, which are extensively used in ornamental plantings.

Mulberries are propagated from seeds or by grafting, budding, layering, and cuttings. In propagating the plant for use in hedges or shelter belts the plants are grown from seeds, but for fruit purposes grafting, cutting, or layering must be resorted to in order to produce varieties true to name.

> Most species of mulberries are easily propagated by means of cuttings. And while the most satisfactory and most economical plan is to use one-year-old branches for this work, twigs of the current season's growth may also be used. Cutting wood may be removed from the trees soon after the leaves have dropped. Select well-matured, well-developed one-year-old branches from one-quarter to five-eighths inch in diameter. Cut these into pieces, each being provided with from three to six good buds. In eastern North Carolina the cuttings may be planted immediately after removal from the trees, but in the colder sections it is usually best to tie them together in bunches of twenty-five and store them in damp sand in a cellar or pit until spring.

The cuttings are set out in well-prepared soil, making an opening in the ground with a spade, firmly pressing the soil about the base of the plants, and covering up to the top bud. It takes longer to produce trees by this method than by budding or grafting. Bench grafting by either the whip, cleft, or saddle method is used; or the trees may be grafted out of doors, using either the cleft or whip method. In the South, Multicaulis mulberry stem or root cuttings are used almost exclusively as stocks, while in the colder West and Northwest, Russian mulberry seedlings are used as stocks.

In the orchard, large growing trees like New American, White English, and Black English should be planted about 30 feet apart, and for such varieties as Stubbs and Hicks 35 feet in the row is close enough between trees. The trees should be set out in the usual manner by cutting off all broken and bruised roots, shortening in the longer roots somewhat, and cutting back the top.

According to Hume and Reimer—

> The mulberry needs little or no cultivation. When planted in chicken yards or where hogs are allowed to run and root, no extra cultivation need be given. They will thrive in soddy land; but generally the trees do better where the soil is stirred or worked, as in hog pastures. If any cultivation is given it should be shallow, as the roots spread out near the surface of the ground. Deep plowing should not be practiced. The mulberry requires little or no pruning. But as the wood is rather brittle and the branches are easily broken by sleet storms, the stubs which are left should be cut off close up in the trunk and the broken branches cut smoothly off at the ends.

Wild mulberries have been used since the earliest times in America; Hariot, in his Narrative of the First Plantation of Virginia, which was first printed in 1588, mentions that the Indians used mulberries, crab-apples, and huckleberries, such as were known in England; but the mulberry has occupied a less important place in the list of foods than most other edible native fruits and berries. The quality of the wild fruit is known to vary greatly, some trees yielding berries of excellent flavor and appearance while others produce small and very inferior berries. The fruit of cultivated and improved varieties of mulberries is much superior to the native fruit, and has been long appreciated though never common in the United States. Old gardens in Eastern and Southern States and New England often contain a mulberry tree, and the fruit has been used in a limited way for the table and for preserving.

In flavor and appearance, mulberries, particularly the dark varieties, resemble blackberries more nearly than they do any of the other common fruits. The flavor is sweet and rather aromatic, though not as pronounced as that of the blackberry, and to some palates it is always accompanied by a suggestion of the peculiar and elusive odor noticed when mulberry leaves are crushed.

The color of the dark-fruited varieties is intense, and as the berries are soft and easily crushed they stain the fingers or table linen very readily.

According to analytical data reported some years ago by a German investigator, cultivated mulberries contain 84.7 per cent water, 0.4 per cent protein, 14.3 per cent carbohydrates, and 0.6 per cent ash. According to American analyses, blackberries, on an average, contain 86.3 per cent water, 1.3 per cent protein, 1 per cent ether extract, 10.9 per cent carbohydrates, and 0.5 per cent ash, values which in general are much like those quoted for mulberries. In the case of blackberries, about 6 per cent of the total carbohydrates has been found to be invert sugar, and in the case of mulberries about 9 per cent. Of course, the kind and amount of sugar would be influenced very greatly by the degree of ripeness.

Mulberries can be used as a dessert fruit, and also for making pies, puddings, jellies, jams, etc., in the same way as more common berries. The expressed juice is bottled to some extent in Europe, like raspberry juice and other fruit juices, and mulberry wine is also made. The long fruiting season and the generous yield are points in favor of the mulberry for table use.

ALFALFA CULTURE IN THE EASTERN UNITED STATES.[a]

While alfalfa is quite generally grown west of the Missouri River it has not made similar progress in the eastern sections of the country, although attempts to cultivate it were made a century ago in New York and other Eastern States. For many years the successful culture of alfalfa was considered as limited to the region west of the Mississippi and south of the Minnesota-Dakota line. In more recent years, however, its culture has steadily spread eastward and northward until the crop is grown with more or less success in all of the Eastern States and in such northern latitudes as Minnesota, Wisconsin, northern New York, Vermont, Ontario, and Quebec. The experience gained in most of the early trials, and even some later ones, was not as a rule encouraging, and the efforts to grow alfalfa were generally abandoned. Interest in the crop, however, was reawakened later on, and during recent years many culture tests have been conducted by the eastern experiment stations and by this Department. One of the principal reasons why alfalfa grows more successfully over extensive regions in the West is thought to be the greater uniformity of soil conditions over larger areas than in many of the Eastern and especially the Atlantic coast States. Another reason is that the movement in alfalfa culture in this country progressed from west to east, and as the earlier settlers of the West located in the most favorable spots the culture of alfalfa had the advantage of being introduced where it had the greatest chance of succeeding, while in the more thickly settled States it is often tried under conditions unfavorable to its growth. Although the more or less general introduction of the crop in certain sections has brought many failures, it has also demonstrated that there are numerous localities, and often considerable areas, over which the crop may be grown with success in the East. The great value of alfalfa for feeding purposes and soil improvement makes it well worth while to continue culture experiments for the purpose of ascertaining under what conditions and in what localities its general culture may be attempted with promise of success.

---

[a] Compiled from Alabama College Sta. Bul. 127; Delaware Sta. Bul. 55; Illinois Sta. Bul. 76; Indiana Sta. Bul. 101; Maine Sta. Bul. 126; Maryland Sta. Bul. 85; Michigan Sta. Bul. 225; Mississippi Sta. Rpt. 1904, p. 13; New Jersey Stas. Buls. 148, 190; New York Cornell Sta. Bul. 237; Ohio Sta. Circ. 49; Pennsylvania Sta. Bul. 79; Vermont Sta. Bul. 114; Virginia Sta. Bul. 154; Wisconsin Sta. Bul. 121.

The wide adaptability of alfalfa and the possibilities of its culture east of the Mississippi are indicated by the measure of success which has attended the more recent attempts to grow the crop in Alabama, Delaware, Illinois, Indiana, Maine, Maryland, Michigan, New Jersey, New York, Ohio, Pennsylvania, South Carolina, Vermont, Virginia, and Wisconsin under a great variety of soil and climatic conditions. The more important practical facts brought out in investigations by the experiment stations in some of these States are summarized below.

Experiments with alfalfa have been carried on for a number of years in Alabama by farmers and by the experiment station in cooperation with farmers and with this Department. Summing up the results, J. F. Duggar says in a recent bulletin of that station:

> Alfalfa is a perennial leguminous plant, useful for hay, feeding green, pasturage, and for soil improvement. In nutritive qualities alfalfa stands in the front rank, and when fed to farm teams the ration of corn can be greatly diminished. On suitable soil the yield of hay exceeds that of any other hay plant. On prairie soils in Alabama yields of more than 3 tons per acre were in two instances obtained within seven months after sowing the seed, and the yield continues to increase for several years. Farmers report 3 to 5 tons per acre as the usual yield of hay per acre on prairie soil in Alabama, and in a number of instances these yields are greatly exceeded.
>
> Alfalfa makes an unrivaled hog pasture, and is also recommended as a pasture plant for horses and mules. Cattle and sheep sometimes bloat when grazing on alfalfa. Pasturing, especially during the first year, injures and sometimes kills alfalfa.

In experiments made by A. T. Neale, of the Delaware Station, alfalfa gave much larger yields of feed than crimson clover or cowpeas, even when harvested within five months after seeding. This, however, is considered an unusual result.

The earlier attempts to grow alfalfa on Illinois soils failed because, as C. G. Hopkins, of the Illinois Station, points out, the alfalfa bacteria were generally lacking in the soils, and in some cases lime and phosphoric acid were needed. When these deficiencies were supplied alfalfa has generally been successfully grown in the State on well-drained soils.

Experiments reported by A. T. Wiancko and M. L. Fisher, of the Indiana Station, show that a good stand of alfalfa may be obtained with proper inoculation on almost any of the soils of Indiana, but especially on the more open soils.

Experiments in different parts of Maine, reported by C. D. Woods and J. M. Bartlett, of the Maine Station, showed such a low degree of success that "the station does not advise anyone in this State to grow alfalfa at present, except in an experimental way."

Summing up the results of observations and experience during a number of years, W. T. L. Taliaferro, of the Maryland Station, says:

> Numerous attempts have been made in recent years to grow alfalfa in Maryland. For the most part these efforts have been failures, and the impression has been pretty generally formed that our soil and climate are not adapted to its growth. Some of the efforts have, however, succeeded, enough of them and in such widely separated localities as to show clearly that the successful growing of alfalfa in this State is mainly a question of local soil selection. There is no doubt that with more experience in handling it and a better knowledge of the conditions it requires there are in every county in Maryland thousands of acres which might be, and ultimately will be, put into alfalfa.

Trials of alfalfa were begun by the Michigan Station as early as 1889. Of this work C. D. Smith says:

> The station has distributed alfalfa seed for trial to over 150 farmers. The United States Government has also distributed seed to many farmers in the State, and the records of these plats have been turned over to this station. Of 76 reports from farmers who have tried alfalfa, 32 record absolute failures, due generally to winterkilling; 24 record partial success for a single year; 16 record success for two or more consecutive years.

The principal cause of failure is winterkilling. Whether varieties sufficiently hardy to generally withstand the severe winters of the State can be found is yet to be determined, according to Professor Smith.

E. R. Lloyd, of the Mississippi Station, reports that 2 acres of alfalfa at that station pastured 14 pigs two months and gave 6,541 pounds of hay.

In a bulletin of the New Jersey stations G. A. Billings makes the following statement:

> A few years ago it was supposed that alfalfa was a plant which could be successfully grown only by irrigation. We find to-day, however, that it can be grown on varying conditions of soil and climate, from the bottom lands of the Red River in Louisiana and the Yazoo delta of the Mississippi in the South, to Minnesota, Wisconsin, New York—even as far north as Ottawa and southern Quebec, and from the Atlantic to the Pacific oceans. * * * A five years' experiment at this station gave an average yield of 19.32 tons of green forage per acre. The largest yield, namely, 26.6 tons, was grown the third year. Reports from different parts of this State indicate that farmers are following the suggestions of this station, and are successfully growing the crop. The acreage is rapidly increasing, and the stand on newly seeded fields is excellent.

The New Jersey Station experiments show that on account of its large yield and high nutritive value, especially protein content, alfalfa may be profitably used to partly replace purchased concentrated feeds in rations for farm animals.[a]

The New York Cornell Experiment Station has experimented with alfalfa on the college farm at Ithaca and in cooperative trials throughout the State and has secured results affording suggestions helpful to Eastern alfalfa growers.

During the winter of 1903–4, which was unusually severe, considerable damage was sustained by the alfalfa fields of New York. Of 86 responses to a circular of inquiry sent out by the station 67 reported damages to the crop during the winter. The replies further indicate that alfalfa was grown on a wide range of soils, including those with heavy clay and hardpan subsoils. Good success was reported in a number of cases on fields with heavy subsoil, but it was observed that the fields in which the losses were reported as considerable all had heavy clay or hardpan subsoil, the heaviest losses being sustained on the soils with the heaviest subsoils, while the fields from which little or no damage was reported nearly all had porous subsoils. Only one of the fields reporting no injury had a hardpan subsoil. From the results of this inquiry it is concluded that while alfalfa does succeed in some instances on lands with more or less impervious subsoils it is much more likely to be injured by severe winter seasons than on lands underlaid with subsoils of a greater porosity. The failures of the first attempts with the crop are attributed to its growth upon lands unsuited to its culture and to improper management due to inexperience in handling it.

---

[a] U. S. Dept. Agr., Farmers' Bul. 251, p. 26.

The results secured in 1904 and 1905 corroborated the conclusions of the previous year by emphasizing the importance of suitable soils, their thorough preparation, their adequate fertility, their freedom from weeds, the use of good pure seed, the application of lime in most cases, and inoculation with the proper nitrogen-gathering bacteria.

C. G. Williams, of the Ohio Station, states that, while the acreage devoted to alfalfa in Ohio is not large, it is increasing quite rapidly. He believes that the culture of alfalfa "may be undertaken with reasonable hope of success upon almost any well-drained limestone soil in the State. Its success upon other soils is not as well assured, although the indications are that with proper treatment, including a liberal application of lime, it can be made to do fairly well in most sections.

"Drainage, either natural or artificial, is the first essential. An excess of water in the soil is fatal to alfalfa. While it will stand an overflow of several days' duration at certain seasons of the year, it will not thrive upon land where the water-level is close to the surface, or where water does not drain off rapidly."

G. C. Watson, of the Pennsylvania Station, reports varying degrees of success in attempts to grow alfalfa in that State during the last six or eight years, but states that many of the trials were made under conditions not well suited to the growth of the crop. "Under favorable conditions alfalfa yields a most satisfactory crop for soiling and for hay."

In 56 trials in different parts of Vermont reported by J. L. Hills and L. R. Jones, of the Vermont Station, 12 were classed as permanent successes, the rest as failures or temporary or partial successes. The larger proportion of the successful trials occurred in the Champlain

Valley, where soil (limestone) and climatic conditions are more favorable than elsewhere.

In a recent bulletin of the Virginia Station, by A. M. Soule and Meade Ferguson, it is stated that "alfalfa is being grown with success in various parts of Virginia, and the indications are that it will do well in humid climates providing the soil is brought into suitable conditions for its growth."

A bulletin of the Wisconsin Station, by R. A. Moore and others, states that "alfalfa can be grown successfully under proper conditions in all counties of Wisconsin. * * * No forage plant has so preeminently come to the front in the State during the past five years as has alfalfa." In experiments at the Wisconsin Station alfalfa gave much larger yields and more protein per acre than clover, timothy, or brome grass.

The essentials of successful alfalfa culture in the Eastern United States are here briefly summarized from the station publications above referred to. Deep well-drained soils with porous subsoils are best suited to alfalfa. Observations made by the New York Cornell Station indicate that the upland stony and shaly loam soils in the northern two-thirds of the State are better suited to alfalfa than the soils in the southern third, which are generally compact shaly silt and clay loams with a dense subsoil. Good yields of alfalfa have also been secured on gravels and gravelly loams. The soil should be well supplied with lime (although applications of this substance have not always proved beneficial), as well as with potasn and phosphoric acid, and if it is not well inoculated there should also be an abundance of readily available nitrogen present. The soil may be inoculated (1) by means of infected soil, or (2) by the use of pure cultures of the nitrogen-fixing organisms. In the first method soil from a field in which alfalfa has grown and produced abundant root tubercles is scattered over the field at the rate of 100 pounds per acre just before the seeding. The second method is fully described in a Farmers' Bulletin of this Department.[a] In experiments made by the New York Cornell Station the first method was almost uniformly successful, leading to the conclusion "that this method of inoculation when needed will not fail of giving results unless the soil is in such condition that the bacteria can not live in it."

It is absolutely essential that the young plants especially should have the most favorable conditions possible for growth, for as G. A. Billings of the New Jersey Station says:

> The young alfalfa plant is one of the weakest among farm crops, grows slowly, is easily checked or killed by weeds, or by unfavorable conditions of the soil, weather, or treatment. The seed bed is therefore of prime importance, and the greatest care must be taken to give the young plants plenty of available plant food and best soil conditions for the first year of their growth.

---

[a] U. S. Dept. Agr., Farmers' Bul. 239.

The treatment of the field for the season preceding should be such as to effectually subdue all weeds, and cause the sprouting and destruction of weed seeds in the soil. Care should be taken not to introduce them with manure. Apply manure, therefore, on the previously tilled crop or after the alfalfa crop is established.

The soil should be thoroughly prepared—this is important—to secure a good stand. For spring planting, it is preferable to plow in the fall. If, however, alfalfa is to be planted on land freshly plowed, the surface should be firmed with a roller, then fined to a depth of 3 inches to prevent loss of moisture. Provided the surface is kept pulverized, the longer the seeding is delayed after plowing the better, and many failures may be due to careless work at this time.

Summer or fall seeding following thorough tillage often proves preferable to spring seeding, which is more likely to be choked out by weeds. Somewhat heavier seeding (20 to 30 pounds per acre) than is common in the West has generally been found preferable for the Eastern States. Liberal applications of barnyard manure are especially beneficial to alfalfa.

With early seeding on very weedy land it may be beneficial to seed with a nurse crop; with late seeding the nurse crop may be omitted.

OAT CULTURE IN THE SOUTH.[a]

It is generally believed that the culture of oats is not so well adapted to the Southern States as to more northern latitudes. In most of the Southern States the average yield of the crop ranges from 12 to 25 bushels per acre, while the average yield for the entire country for 1905 was 34 bushels, and the average yield in many Northern States is from 30 to 40 bushels and even more per acre. The total yield and acreage is also largely in favor of the North.

R. J. Redding, of the Georgia Station, points out that the poor results with oats in the South are due to a large extent to poorly selected seed and careless methods of culture, but that one of the main reasons for its limited culture in that region "is the alleged uncertainty of the oat crop, because of the danger of winterkilling, if the seeding is done in the fall, and the liability to rust or injury from drought, if sown in the spring." He, however, gives it as his opinion, "that under proper conditions, most of which are under our control, or subject to modifying precautions, the oat crop can be made a more certain crop than corn."

Experiments made by several Southern experiment stations have shown that at least much better results with oats than those indicated by the crop statistics can be secured in many localities. Experiments extending over a period of ten years have recently been summarized by J. F. Duggar in a bulletin of the Alabama Station, and the results obtained are here briefly reviewed to show by what methods an improvement in yield may be effected and the culture of the crop generally advanced.

---

[a] Compiled from Alabama College Sta. Bul. 137; Alabama Tuskegee Sta. Bul. 8; Arkansas Sta. Bul. 66; Georgia Sta. Bul. 44; Louisiana Stas. Bul. 72; South Carolina Sta. Bul 103.

In 1905 Alabama produced 3,165,574 bushels of oats on 191,853 acres, the average yield per acre being 16.5 bushels. Professor Duggar urges an increase in the acreage devoted to the crop and believes that the average yield may be more than doubled at slight expense by employing the proper methods. The different factors entering into the problem are time and manner of sowing, varieties to be grown, and the fertilizers to be used together with the methods of their application.

It is pointed out that among the numerous varieties of oats, comparatively very few have shown themselves well adapted to the Gulf States, the standard southern varieties being Red Rust-Proof, Appler, Culberson, Burt, and Turf or Gray Winter. The last-mentioned variety is also known as Virginia Gray. In tests conducted at the station, Red Rust-Proof, also known as Texas Rust-Proof, and regarded as the standard variety for the Gulf States, gave the best general results. Appler, a selection from Red Rust-Proof, in three tests yielded 6 per cent more grain than the parent variety, and Culberson, also apparently a strain of Red Rust-Proof, ranked equal to its parent in merit. Turf, or Gray Winter, gave an average of only 59 per cent as much grain as Red Rust-Proof when sown as late as November and apparently did not equal this variety when sown in its regular season in September or October. Turf oats sown in the spring was an entire failure. While Turf oats is hardier than Red Rust-Proof, it is not considered preferable for fall sowing, where the Red Rust-Proof ordinarily succeeds. Burt and May (apparently the same variety) when fall sown and after passing through a mild winter produced 89 per cent as much grain as Red Rust-Proof and 93 per cent as much when both varieties were sown in the spring. Burt is a spring variety and is seldom sown in the fall. During the past eleven years Red Rust-Proof grown at the station was practically all winterkilled but once, while after other trying seasons fair yields were obtained, although the stand of the crop had been reduced.

In experiments by C. L. Newman, of the Arkansas Station, "three varieties of fall-sown oats gave an increased yield of 75.2 per cent over twenty varieties of spring-sown oats. Culberson and Virginia Gray (Winter Turf) oats gave highest yield from fall sowing and averaged over 40 bushels per acre. The varieties giving best returns from spring sowing were Burt, Clydesdale, Culberson, Negro Wonder, Rust-Proof, Virginia Gray (or Winter Turf), and White Maine, all of which gave an average yield of more than 30 bushels per acre."

The general outcome of a series of experiments by the Alabama Station bearing on the time and manner of sowing confirm the results of similar experiments by the Georgia Station, and was that fall sowing gave much better returns as regards winterkilling than spring sowing. The results obtained in experiments during seven different years show that red Rust-Proof sown in November gave an average increase in yield of 11.3 bushels per acre over crops of the same variety sown in February. This represents a profit of $5.65 per acre, or an increase of 73 per cent, due to fall sowing. In these experiments the average date of fall sowing was November 17, but other tests have shown that this is too late for maximum yields, and that sowing in October is likely to give larger yields and to produce hardier plants. October sowing is recommended, although it is believed that satisfactory yields may be secured by sowing on any date from September 1 to November 15. Sowing in October has the advantage of enabling the plant to develop a strong root system before winter sets in, and thus making it better able to withstand severe weather. The advantages of fall sowing are enumerated as follows: (1) A much larger yield, even after deducting the losses from partial winterkilling; (2) the utilization of poorer land by the fall-sown crop; (3) the employment of teams at a time when they are not needed in preparation of land for cotton or corn, and (4) earlier maturity of fall-sown oats, permitting the use of the crop and the use of the land at least two weeks earlier than when oats are sown after Christmas. The first few days of February are considered best for spring sowing in the latitude of the Arkansas Station. Deep plowing and thorough preparation of the seed bed are especially urged by this station among others.

The method of sowing oats found by the Alabama Station to be highly satisfactory and most effective in reducing or preventing winterkilling is much the same as that recommended by R. J. Redding, of the Georgia Station, several years ago, and consists in opening deep furrows 18 to 24 inches apart and drilling the seed and fertilizer in the bottom of these furrows, barely covering the seed with the earth falling into the furrow as the one-horse planter and fertilizer distributor passes along. The primary object of the method is to prevent the young plants from being heaved by alternate freezing and thawing. As Director Redding states in a bulletin of the Georgia Station—

> The plants come up 1½ to 2 inches below the general surface, and the "crown" of each plant is formed and established, say, 2 to 2½ inches below the general surface. The winter rains, light freezes, and thaws gradually but only partly fill in the open furrow, and the more vital and sensitive parts of the plants are left at the original depth, below the reach of even very severe freezes.

For four years the Alabama Station compared this method with broadcasting, and also with a modification consisting in nearly or quite filling the deep furrows after sowing, with results generally favoring seeding in partly filled furrows.

> For well-drained soils there are decided advantages in drilling fall-sown oats in deep furrows, especially when the winter proves severe. It is advisable, where practicable,

to run the rows perpendicular to the line of the coldest winds, which would give the rows a direction from southeast to northwest, or east and west.

These recommendations are in accord with Director Redding's results, from which he concludes "that the ideal direction would be northeast and southwest, in order to protect the plants, by means of the wall of earth, against the northwest wind."

On fields in which the young plants had been heaved by alternate freezing and thawing the Alabama Station secured good results by using the land roller when the soil was in proper condition and not too wet. The purpose of this treatment is to press the exposed crowns of the heaved plants back into the soil in order to facilitate the formation of new roots and the continuance of growth.

Fertilizer tests conducted by a number of experiment stations have shown that nitrogenous fertilizers, particularly nitrate of soda, are especially effective on oats. The Alabama Station found such fertilizers more profitable than phosphate or potash on the sandy and loamy soils of that region, but it is recommended that on such soils at least 100 pounds of phosphate per acre be applied at the time of sowing oats. It was further shown that nitrate of soda was more effective than cotton-seed meal and the latter than cotton seed. The Georgia Station found that "cotton-seed meal is an excellent fertilizer for oats on ordinary old lands," but that top-dressings of nitrate are advisable. Professor Duggar advises that where cotton seed or cotton-seed meal is used, the application be made at the time of sowing, but that nitrate of soda at the rate of 60 to 100 pounds per acre be given as a top-dressing in March after growth has begun. Barnyard manure greatly increased the yield of oats in the Alabama experiments, and also exerted an influence on the following crop: In one experiment 43.1 pounds of nitrate of soda and 103 pounds of acid phosphate, representing a total cost of $1.93, were required to produce the same increase as 1 ton of fine, fresh, unleached horse manure. As shown in 13 tests with nitrate of soda, the yield and total profit per acre increased with the quantity applied up to 200 pounds per acre. The cost of nitrate of soda required to produce 1 additional bushel of oats was 14.5 cents from the use of 63 pounds per acre, 17.7 cents from the use of 100 pounds, and 21.1 cents from the use of 200 pounds. The smallest application gave a profit over the cost of fertilizer of 249 per cent; the application of 100 pounds, a profit of 206 per cent on the cost of the fertilizer; and the application of 200 pounds, a net profit of 140 per cent—the money profits per acre being $4.73, $6.19, and $8.40 for the 3 applications, respectively.

No nitrogen need be purchased for oats, provided the oats be sown after a crop of cowpeas, velvet beans, peanuts, or soy beans, all of which crops, whether only the stubble or the entire growth was plowed under for fertilizer, afforded an increase in the succeeding oat crop of from 6.2 to 33.6 bushels per acre. From 5 to 15 bushels increase in the succeeding oat crop is considered an average result of the use of the stubble or vines of leguminous crops employed as fertilizer.

The station was successful in preventing smut in the crop by soaking the seed in a mixture made up in the proportion of 1 ounce of formalin to 3 gallons of water.

The work of the experiment stations referred to would seem to demonstrate that oats could be grown to greater extent with profit in the South, provided, as Professor Duggar says, " farmers will make the two following innovations in the usual method of caring for the crop: (1) Sowing in the early or middle fall, (2) applying nitrate of soda as a top-dressing in March, or sowing on land where a soil-improving crop, like cowpeas, has recently grown." The certainty and profit of the crop will be still further increased by more attention to selection of varieties and seed, thorough preparation of land, methods of seeding, and protection from smut.

IMPROVEMENT OF GRASS LAND.[a]

In a bulletin of the West Virginia Station, J. H. Stewart and Horace Atwood report trials of a system of manuring by which "an unfertile upland meadow was made to produce an average yield for six years of more than three tons of hay per acre, the yields gradually increasing from a little more than 1½ tons per acre the first year to a maximum of more than 5½ tons of hay per acre the last year."

The field used in this experiment has been used for the production of various crops from the time when this section of the country was first settled, and as no commercial fertilizer, and only a very limited amount of stable manure, had been applied to it, the readily available fertility of the soil had been nearly exhausted.

For the first year's experiment manure was applied during the preceding winter (1899–1900) to two-thirds of the field at the rate of twenty-five loads per acre.

The manure was obtained from livery stables in Morgantown and was spread on the meadow directly from the wagon. Just before the grass began to grow in the spring, the stable manure plat was thoroughly harrowed with a smoothing harrow so as to break all the lumps and distribute the manure uniformly over the surface of the ground. The remaining third of the field received an application of 200 pounds of sodium nitrate per acre, applied with a grain drill in the latter part of April.

The manure cost 50 cents per load at the stables, and about $1 per load when spread upon the field. The sodium nitrate cost $45 per ton. * * *

Early in the autumn of 1900 the entire meadow received an application of 400 pounds per acre of acid phosphate. In the winter the stable manure plat received a further dressing of twelve loads per acre of manure, while early in May the commercial-fertilizer plat received a dressing of 125 pounds of sodium nitrate, 125 pounds of acid phosphate, and 72 pounds of potassium sulphate per acre. * * *

The third year of the test the stable-manure plat received an application of ten loads of manure per acre. It was harrowed thoroughly in March and then rolled. The fertilizer was applied to the commercial-fertilizer plat April 19, at the rate of 110 pounds of acid phosphate, 80 pounds of sodium nitrate, and 40 pounds of potassium sulphate per acre. * * *

---

[a] Compiled from West Virginia Sta. Bul. 101.

The fourth year of the test the stable-manure plat received a dressing of twenty loads per acre of manure applied in October and November. As in former years, this plat was harrowed thoroughly in the spring and rolled. The commercial fertilizer was applied to the other plat at the rate of 400 pounds of sodium nitrate, 800 pounds of acid phosphate, and 150 pounds of potassium sulphate per acre. This was applied as a top-dressing April 20. * * *

The fifth year of the test both plats received the same kind and amount of fertilizer as in the preceding year. The commercial fertilizer was applied April 11, and the stable manure during the fall and winter of 1903–4. * * *

The sixth year of the test the stable-manure plat received a dressing of fifteen loads of manure per acre applied in the autumn of 1904. As in previous years, this plat was thoroughly harrowed in the spring. The commercial-fertilizer plat was fertilized the same as the year before, namely, at the rate of 400 pounds of sodium nitrate, 800 pounds of acid phosphate, and 150 pounds of potassium sulphate per acre. This mixture was applied with a grain drill, April 21, 1905.

The grass grown was mainly timothy, and the hay crops were sold at prices ranging from $12 to $16 per ton, averaging nearly $15 for the whole period of the experiments. The results for the six years are summarized in the following table:

Results of 6 years' experiments in manuring a meadow.

Year.	Yield of hay per acre on plat fertilized with—		Value of hay per acre on plat fertilized with—		Cost of fertilizer per acre on plat fertilized with—		Value of crop less cost of fertilizer per acre on plat fertilized with—	
	Stable manure.	Commercial fertilizer.	Stable manure.	Commercial fertilizer.	Stable manure.	Commercial fertilizer.	Stable manure.	Commercial fertilizer.
	Pounds.	*Pounds.*						
1900	3,775	3,232	$28.31	$24.24	$25.00	$4.50	$3.31	$19.74
1901	7,219	6,095	54.14	45.71	14.70	8.15	39.44	37.56
1902	7,961	5,602	58.08	41.59	10.00	3.49	48.08	38.10
1903	7,411	7,312	55.56	57.01	20.00	18.15	35.56	38.86
1904	10,588	8,088	76.79	60.66	20.00	18.15	56.79	42.51
1905	11,315	7,955	80.68	59.16	15.00	18.15	65.68	41.01
Averages	8,044	6,380	58.92	48.06	17.45	11.76	41.47	36.29

The stable-manure plat gave an average yield of 1,664 pounds of hay per acre more than the commercial-fertilizer plat; yet on account of the extra cost of the manure as compared with the commercial fertilizer, the value of the crop, less the cost of the fertilizer, was only $5.18 larger per year. However, under ordinary farm conditions, the cost of a two-horse load of manure spread upon the land is far less than $1 per load, so in reality the difference in profit is considerably larger than is shown by the table. In addition to this difference the stable-manure plat is in a far better condition, agriculturally, at the end of the sixth year than the commercial-fertilizer plat. The soil of the former is full of decomposing vegetable matter, and is soft and yielding to the tread, while the soil of the commercial-fertilizer plat is hard and compact. The open and porous soil of the stable-manure plat enables this soil to store up more moisture, so that a crop growing thereon would be less likely to be injured by drought than is the case in the other instance.

However, both systems of manuring were highly profitable and show that "large crops of grass can be grown upon soils of this class, provided sufficient plant food is supplied for the needs of the crop."

Incidentally, it was observed that stable manure "applied to meadow land in the fall and thoroughly harrowed in the spring becomes so disintegrated and incorporated with the surface of the soil that it is not raked up with the hay when the hay is harvested."

SUCCOTASH AS A SOILING CROP.[a]

This term, originally applied by the North American Indians to a mixture of green corn and beans prepared for human food, has in recent years come to be used also to denote mixtures of some leguminous crops, such as peas or beans with corn and one or more other cereals grown as soiling crops.

In view of the fact that numerous mixtures of this kind have been tried in different parts of the country with varying success, R. S. Shaw, of the Michigan Station, has made a series of experiments to determine the most satisfactory rotation of mixed soiling crops for swine and one which would cover the greatest possible portion of the year.

The first mixture, grown in 1903, consisted of corn, peas, oats, and barley. Though this combination produced a large tonnage of green food, it made but one crop in the season, as all of the plants in the mixture failed to make a second growth after having been cut or grazed off. With the object of securing a second growth in the season of 1904, the mixture was changed to the following, viz.: Corn, peas, oats, rape, and millet. This combination was successful in producing a second crop of rape and millet when the first crop was cut with the scythe, but not when closely grazed off. Within eight weeks from the time of the first cutting this second crop was nearly knee high; but it was mostly rape, as the millet could not keep pace with it in growth. The success thus achieved in securing a second crop of rape and millet created the desire to combine some leguminous plant with the rape in place of the millet. As a result the four sowings of the spring of 1905 were made up as follows, viz.: Corn, peas oats, rape, and clover.

The full value of this mixture has not yet been determined, but Professor Shaw is of the opinion that it "is an extremely useful combination and that it can be produced as regularly and successfully as any other crop or mixture if properly handled."

He has found it especially valuable as a soiling crop for dairy cows because of the fact that it fills in a gap between the possible use of green clover and green corn, and also highly satisfactory for young calves being housed during the heat of the summer.

Though the first attempt was to use this mixture as a forage crop for swine, it has not proved to be so valuable for that purpose as was expected. * * * When the succotash was grazed off by swine the losses were heavy from the trampling and wallowing of the animals; in fact, so much so that it had to be hurdled off, giving them access to but a limited area every few days, and this is a somewhat expensive and troublesome method. When cut, hauled, and fed in the hog lots or pens there was little or no loss. When the rape and clover plants were bitten off close to the ground by hogs many of them failed to grow again; when cut higher with a scythe they did not fail to grow. Succotash may be objected to for the dairy cow because of the large amount of water it contains, but it nevertheless furnishes the succulence so necessary to supplement her ration while on dry and exhausted pastures. This food was used for the college dairy herd during the season of 1905 between the time the silage was exhausted and green corn became available. The composition of succotash does not vary greatly from that of green corn in the earlier stages, when used for soiling purposes. The question naturally arises, Would it not be better practice to supplement the failing pastures with silage rather than succotash? We should answer yes, providing one has the silage, but at the present time all dairymen are not possessed of silos and most of those in use are generally empty long before midsummer. Should succotash be grown for such emergencies and not needed, it can be cut and cured for hay when the oats are in the milk or dough stage. The small amount of rape in the first cutting has not tainted the milk so far as used.

---

[a] Compiled from Michigan Sta. Bul. 235.

The second growth of rape and clover must needs be less of a certainty than the first crop of the original mixture, as favorable conditions for growth usually diminish as the season advances, owing to greater heat and lack of moisture. A lodged crop can not remain in that condition long without injuring the clover and rape; for their benefit the crop should be cut as quickly as possible. If succotash is grown to any great extent for soiling purposes it should be sown at two or three different dates, the first late in April or early in May, the others following at intervals of ten days or two weeks. From the different dates of seeding some one or more of the lots is almost sure to produce a second growth suited for sheep or swine pasture and probably for some other classes of live stock also. The ability to secure a crop of clover on the same ground the next season, for pasture or soiling, is at present uncertain, but is well worth trying for.

The conditions and methods of culture suited to succotash are described by Professor Shaw as follows:

> The ground upon which this crop is grown must be rich. We do not believe large tonnages can be secured from poor land except in unusual seasons when the rainfall is large and favorably distributed. It is not a difficult matter to properly enrich sufficient ground for the crop of succotash. A small area only is necessary, say from one to three acres, to tide the average dairyman over from clover to corn on a failing pasturage. Manure can not well be used to better advantage than on this area. We have found that the manure for this crop should not be buried too deep, for the crop should be induced to start and grow quickly; it is short-lived. Our best results have come from spreading a good coating of heavy manure (not strawy) on the land after plowing and before fitting for seeding; this manure is not allowed to lie on the surface of the ground, but is worked into and incorporated with the top two or three inches of soil by means of the disk and harrow. This plan almost insures a quick and vigorous start of the small seeds, such as clover and rape. After the seed bed has been thoroughly prepared, sow a good seeding of rape and clover mixed, broadcasting it, and then follow with the seed drill burying the mixture of corn, peas, and oats at the proper depth; the drill will cover the small seeds previously sown on the surface. In general the grain mixture should be sown at the rate of about two bushels per acre.

In the experiments reported a mixture of equal parts of rape and clover was sown at the rate of 3 quarts per acre, the rest of the seeding consisting of a mixture of equal parts of corn, oats, and peas.

TANKAGE AND BONE MEAL FOR HOGS.[a]

The widespread interest in by-products of animal origin as supplements to corn in swine feeding led the Michigan and Nebraska experiment stations to undertake several tests to determine whether tankage, one of the most important of such materials, and ground bone can be profitably fed.

---

[a] Compiled from Michigan Sta. Bul. 237; Nebraska Sta. Bul. 94.

Tankage is usually prepared from refuse materials from slaughtering, such as digestive organs and their contents, flesh scraps, and some blood, and condemned carcasses which can not be used for human food, by cooking under steam pressure and then drying and grinding until almost as fine as middlings. The tankage used in the Nebraska tests is described by the company producing it as "a concentrated protein meal made from fresh, wholesome pieces of meat trimmed from beef carcasses. It looks much like dark-colored wheat shorts, is shipped in 100-pound sacks, and will keep indefinitely under average conditions of dry storage." The tankage used in the Michigan experiments was guaranteed to contain 60 per cent protein, 10 per cent fat, and 6 per cent phosphates. It was rich in flesh-forming materials and fat, as well as in bone-building material, which is true of tankage generally.

In the first test at the Nebraska Station hogs averaging 170 pounds in weight made an average gain of 65 pounds each in eight weeks on soaked corn, 5.3 pounds of feed being required per pound of gain, and the cost of a pound of gain being 3.76 cents. In the case of a similar lot fed 95 per cent soaked corn and 5 per cent tankage, the average gain was 81 pounds per head, the feed required per pound of gain being 4.6 pounds and the cost 3.6 cents. On a ration of 90 per cent corn and 10 per cent tankage the average gain in six weeks was 73 pounds per head, the cost of a pound of gain being 4.3 cents and the feed required per pound of gain 5.2 pounds. The pigs were sold for $4.90 per 100 pounds and E. A. Burnett, who carried on the experiments, calculated that the lowest returns per bushel of corn eaten was 47 cents on the ration containing 10 per cent tankage, and the largest return, 57 cents, on the ration containing only 5 per cent tankage.

In a second test, which was made with lighter hogs, the average weight being 144 pounds, the gain on corn alone averaged 71 pounds per head in the eight weeks of the test, on the lighter tankage ration 85 pounds, and on the heavier ration 86 pounds. The feed consumed per pound of gain with each tankage ration was 3.7 pounds and with the soaked corn only 4.2 pounds. The cost of feed per pound of gain on the lighter tankage ration was 2.9 cents, on the heavier tankage ration 3.1 cents, and on soaked corn only 3 cents. The calculated return per bushel for corn eaten was 98 cents in the case of the lighter tankage ration, this value being 20 cents greater than in the case of the lot fed no tankage, and 13 cents greater than in the case of the heavier tankage ration.

When shelled corn was fed instead of soaked corn eight pigs, averaging 67 pounds in weight, fed corn and shorts, 4:1, gained 42 pounds per head in eight weeks. With both tankage rations the gains averaged 58 pounds per head. With these rations 3.5 pounds of feed was required per pound of gain, and on corn and shorts 4.6 pounds. The gain was most cheaply made on corn with 5 per cent tankage, costing 2.7 cents, and was most expensive on corn and shorts, costing 3.4 cents.

In the first of the tests some green sorghum was fed, and in the other cases the pigs were pastured on alfalfa, but no account was taken of the green feed eaten.

> The experiments with relatively mature animals all showed that the addition of 5 per cent tankage to the ration produced cheaper gains than when 10 per cent tankage was used. With young pigs the gains were made on smaller amounts of food when the larger amount of tankage was added to the ration, but the high cost of the tankage has made the smaller amount of tankage more profitable. * * *
>
> A notable advantage in the feeding of tankage is seen in the more rapid gains made by the hogs and the consequent shortening of the feeding period.
>
> Another argument for tankage is that it is a concentrated protein food. Only a small amount is required to produce the result desired.
>
> In all the experiments made at this station, the hogs fed tankage consumed more feed, made larger gains, and were not easily put off feed, while the hogs fed straight shelled corn were easily thrown off feed after the first six weeks, consumed less feed, and made slower gains. From the limited test made we advise adding the tankage to the soaked corn just before feeding, rather than mixing with the corn before soaking and allowing the tankage time to soak and possibly to become rancid before feeding.

In a test which was undertaken primarily to ascertain the effects of feeds of animal origin on the strength of bones both tankage and ground bone were used. For twelve weeks one lot was fed soaked corn, a second lot soaked corn with 10 per cent tankage, a third soaked corn with 10 per cent ground bone, and a fourth soaked corn with 25 per cent shorts. For the following four weeks 10 per cent of the corn was replaced with alfalfa hay, but the pigs did not relish the hay, and so the original ration was resumed for five weeks. At the beginning of the test the pigs weighed about 60 pounds each. Considering the whole period, the lots fed corn and corn and shorts gained, respectively, 114 and 132 pounds per head, while those fed tankage and ground bone gained, respectively, 163 and 164 pounds per head. Three of the largest and best hogs in each lot were slaughtered. The average slaughtered weight on corn was 192 pounds, on the tankage ration 247 pounds, on the ground-bone ration 257 pounds, and on the corn and shorts ration 210 pounds.

Tests of the strength of the bones showed that in every case the bones of the hogs fed the grain ration were not as strong as those fed the ration containing animal products. "The feeding of tankage or ground bone to young growing pigs produces a very marked effect on the strength of bone when compared with a corn ration, and its influence is still marked when compared with corn and shorts on alfalfa pasture."

In the Michigan Station tests, the special problem under consideration was the possibility of substituting tankage for skim milk, since, as pointed out by R. S. Shaw, who carried on the work, so much skim milk is now supplied to cheese factories and condensed milk factories, and to supply the demands of cities and towns, that on many farms there is a scarcity of it for feeding young calves and pigs.

In one of the tests with young pigs corn meal, middlings, and tankage, 3:3:1, mixed with water was compared with the same grain ration mixed with skim milk.

In the other tests a ration of middlings and corn meal, 2:1, with the addition of one-eleventh of tankage wet up with water was compared with the same grain ration mixed with skim milk in the proportion of 1 pound of meal to 3 pounds of milk.

On the tankage rations the average daily gain was 0.98 pound and the feed consumed per pound of gain 3.14 pounds. On the meal and skim milk rations the average daily gain was 1.08 pounds per head and the feed required per pound of gain 2.48 pounds of meal and 5.67 pounds of skim milk. In a check test covering ten weeks, in which two lots of 5 pigs each were fed middlings and corn meal, 2:1, mixed to a thick slop with water, 4.09 pounds of meal were required per pound of gain, the average daily gain being 0.8 pound.

The results indicate "that tankage can be used successfully as a substitute for skim milk in the ration for the growing pig from weaning time on," and "that a slightly greater proportion of tankage than one-eleventh of the ration could be fed, increasing the gains somewhat, and still keeping within the cost of production of the skim-milk ration."

In tests with fattening hogs on corn meal and tankage in the proportion of 5:1 and 9:1 compared with rations of corn meal only and with rations of middlings and corn meal, 2:1, with and without the addition of one-eleventh of tankage, the average daily gain per hog on the tankage rations was 1.19 pounds and on the rations without tankage 0.98 pound. The average cost of a pound of gain with tankage was 4.44 cents and without tankage 4.86 cents.

"The gains were greatest in every case where tankage was used in the ration, and this was more and more noticeable as the feeding period was prolonged. * * * In general, the figures given indicate that tankage can be used to good advantage in the ration for the fattening hog as well as for the growing pig."

The favorable results thus obtained at the Nebraska and Michigan stations with animal by-products in hog feeding are in accord with those reported by the Indiana and Iowa experiment stations and summarized in an earlier bulletin of this series.[a]

---

[a] U. S. Dept. Agr., Farmers' Bul. 169, p. 29.

GRINDING CORN FOR HOGS.[a]

For the past nine years the Wisconsin Experiment Station has been conducting tests to determine whether grinding corn for hogs is desirable. In the tests previous to 1903–4[b] middlings were fed with the corn. That year corn was fed alone, but the results were so unsatisfactory as regards thrift, appetite, gains, and feed consumed per pound of gain that it was not considered desirable to omit the middlings in subsequent years.

The results have varied a little from year to year, but considering the average of all the tests 117 hogs fed dry shelled corn and wheat middlings made an average gain of 96.8 pounds each, while an equal number fed corn meal and wheat middlings gained 110.9 pounds each, the feed required per pound of gain in the two cases being 5.19 pounds and 4.88 pounds. In other words, for each pound of gain the hogs fed shelled corn required 0.3 pound more grain than those fed the corn meal. The saving from grinding, therefore, has amounted to 5.7 per cent. Whether it will pay to grind corn in order to effect a saving will necessarily depend upon two factors, namely, the price of corn and the cost of grinding. When these factors are known the possible saving from grinding can be learned from the following table:

Saving effected by grinding corn for fattening hogs.

	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
Value of corn per bushel	25	30	35	40	45	50	55	60	65	70	75
Amount saved by grinding	1.4	1.7	1.9	2.2	2.5	2.8	3.1	3.4	3.7	3.9	4.2

When corn is worth only 25 cents per bushel the saving from grinding amounts to only 1.4 cents, not enough to pay for the grinding unless cheap power is available. As corn advances in price it will be noticed that the saving per bushel increases practically three-tenths of a cent with each 5 cents' advance in the price of corn. Should the price of corn be as high as 75 cents per bushel the saving by grinding would amount to a little over 4 cents per bushel.

DIPS AS LICE KILLERS.[c]

The harmful effects of infestation with lice are perhaps not fully recognized by stock raisers, and consequently farm animals are often allowed to go without assistance in ridding themselves of these pests. Experiments on the treatment of lice on hogs have been made by a number of the experiment stations and by the Bureau of Animal Industry of this Department, and the results, summarized in a bulletin of the Bureau by E. C. Stevenson, show in general the high practical efficiency of crude or pure kerosene or kerosene emulsion for this purpose.

---

[a] Compiled from Wisconsin Sta. Rpt. 1905, p. 16.

[b] Wisconsin Sta. Rpt. 1904, p. 20.

[c] Compiled from Oklahoma Sta. Bul. 72; U. S. Dept. Agr., Bureau of Animal Industry Bul. 69.

In recent experiments with dips for destroying lice particularly on hogs, L. L. Lewis, of Oklahoma Experiment Station, compared the effectiveness of kerosene or crude oil in various forms and certain proprietary dips of a coal-tar origin. It was soon found that the results obtained from a practical use of coal-tar dips on hogs, under ordinary farm conditions, were not as satisfactory as generally obtained in laboratory experiments. Even in laboratory tests, however, kerosene emulsion containing 5 per cent of kerosene was more effective than 3 per cent coal-tar preparations.

A very satisfactory and inexpensive dipping device was found in a wallowing vat placed so as to be constantly accessible to the hogs. This vat had a depth of about 14 inches and was kept constantly filled with water, being cleaned occasionally and carrying on the surface a gallon or more of crude oil. It was found that the hogs kept themselves free from lice by voluntary immersion in this vat. Coal-tar preparations used under the same conditions did not give the same results, and the hogs were never free from lice after treatment with the proprietary remedies.

One of the defects of the proprietary remedies as compared with crude oil, kerosene, or kerosene emulsion was found to lie in the fact that the proprietary remedies were not nearly so effective in destroying the eggs of the lice as were the various forms of petroleum. According to the experience of Doctor Lewis, if it is desired to spray cattle or treat them with a brush or sponge, kerosene emulsion may be used freely without any fear of harm. For this purpose the emulsion should contain one-half pound of hard soap and 2 gallons of a cheap grade of kerosene in 8 gallons of water.

The Bureau of Animal Industry gives the following directions for preparing this emulsion: Add one-half pound of hard soap (one-half bar of common soap) to 1 gallon of water and boil until the soap is dissolved. Remove from the fire and add 2 gallons of kerosene and agitate vigorously until an emulsion is formed which is gelatinous on cooling. Dilute with warm water to the required strength. The effectiveness of the emulsion is said to be increased by adding 3½ pounds of pyrethrum which is allowed to soak in the kerosene twenty-four hours before the latter is used in preparing the emulsion.

DIGESTIBILITY OF FISH AND POULTRY.[a]

A recently published report of the Connecticut Storrs Experiment Station contains results of a series of studies carried on by R. D. Milner to determine the digestibility of fish and poultry. Salmon was selected as a type of a relatively fat fish and cod steak as a type of lean fish. Similarly in the experiments with poultry, duck was chosen because it is rich in fat and chicken because the fat content is low. The salmon and chicken used were canned products, the cod and duck were fresh goods. Some simple foods like bread, milk, butter, and sugar were eaten with the special foods studied, the whole constituting a simple yet palatable ration.

---

[a] Compiled from Conn. Storrs Sta. Rpt. 1905, p. 116.

The four young men who served as subjects were in good physical condition with apparently normal digestion. Two of them had served as subjects in previous digestion experiments, and the remaining two from their laboratory experience fully understood the nature and requirements of such experiments.

Each experiment covered three days and all the food consumed and the feces excreted were analyzed. The urine excreted on the final day of each experimental period was also weighed and its heat of combustion determined. From the data thus obtained the digestibility of the diet as a whole and that of the fish and poultry alone was calculated in the usual manner. The following table shows the average coefficients of digestibility of the fish and poultry:

Coefficients of digestibility of fish and poultry—Average of four tests.

Kind of food.	Protein.	Fat.	Energy.
	Per cent.	*Per cent.*	*Per cent.*
Salmon (canned)	96.23	97.01	85.63
Cod	95.93	97.40	80.27
Chicken (canned)	96.74	97.13	85.35
Duck	94.66	97.32	91.14

Examination of the results of the individual tests showed that the variations in the coefficients of digestibility were comparatively small; the average for protein of the different foods, for instance, varied less than that of the protein of the same food for the four subjects, being for cod and salmon about 96 per cent, for chicken a little higher, and for duck somewhat lower. The greatest variation was noted with the energy, the highest values being obtained with the salmon and the duck; that is, with the foods containing the largest proportion of fat and hence having the highest energy value.

This may be an indication that the availability of the energy is highest in foods containing a large amount of fat, though the data at hand are not sufficient to warrant too sweeping deductions.

From the results of sixteen experiments in which canned salmon, fresh cod, canned chicken, and roast duck made up in turn a considerable portion of the diet, it appears that these foods are very completely digested, the coefficients of digestibility being approximately those previously found for other animal foods. The foods containing a considerable proportion of fat were apparently as completely digested as those in which the percentage of fat was relatively small. The number of kinds of poultry and fish investigated and the number of experiments carried on with each are too small to warrant further conclusions.

HONEY VINEGAR.[a]

In one of the timely hints for farmers issued by the Arizona Station, A. E. Vinson gives directions based on recent work at the station for making vinegar from honey. It seems that most of the vinegar is supplied to the Territory by eastern makers and the price is abnormally high. Very large quantities of honey are produced in the Territory. This has been used in part by the farmers as a source of vinegar, but the quality of the vinegar made by the usual processes followed by farmers is not up to the standard, and the time required to produce vinegar is so long that many are deterred from making it on a small scale.

The first thing to be considered in making honey vinegar is to secure the complete conversion of the sugar in the honey to alcohol. As is well known, this is accomplished with the aid of yeasts working in the diluted liquid.[b] These yeasts require not only organic but also mineral matter and nitrogen for their best growth. The fermentation starts off much more promptly also if a yeast cake is added.

Honey diluted with ordinary water appears to be lacking in nutrients for the yeast, especially in nitrogen, potash, and phosphoric acid. According to the investigations at the station these materials can best be added to the diluted honey in the form of ammonium chlorid and potassium phosphate, using 1 part each to 1,000 parts solution.

> Unfortunately, potassium phosphate is seldom to be had in the drug stores, and we must rely on other chemicals to take its place. This is best done by using sodium phosphate and potassium sulphate; of each about one part per 1,000. This combination is much cheaper than the rather expensive potassium phosphate and is to be recommended where large amounts of honey vinegar are made. These chemicals can all be obtained in large quantities for about 15 cents per pound. The small producer, who can not afford to buy large amounts at wholesale, will experience much difficulty in getting potassium sulphate, but experiments in this laboratory have shown that potassium bicarbonate, a chemical to be had in every drug shop, can be substituted with nearly as good results. The chemicals are absolutely harmless, and are in no sense of the word to be considered adulterants. Care should be taken to secure well water of good quality, preferably hard, but not too salty.

When a barrel of honey vinegar is to be made for family use or the small producer the following formula is suggested: Strained honey, 40 to 45 pounds; water, 30 gallons; ammonium chlorid, 4 ounces; potassium bicarbonate, 2 ounces; sodium phosphate, 2 ounces. To this should be added about one-quarter of a cake of dry yeast softened in lukewarm water. If the material is now kept at a temperature of 65 to 75° F. the fermentation will be very rapid.

---

[a] Compiled from Arizona Sta. Timely Hints for Farmers, No. 60.

[b] See article on Cider Vinegar, U. S. Dept. Agr., Farmers' Bul. 233, p. 28.

The chemicals for making 30 gallons will cost about 25 cents in a small way, but on a large scale not more than 10 cents. Somewhat larger amounts of potassium bicarbonate and sodium phosphate would give even better results, but the amounts are here cut to the minimum to bring the cost low enough to make it profitable.

In from three to four weeks all visible fermentation will have ceased and the yeast settled out. Now rack off the wine, add 10 gallons of good vinegar, containing a little mother, and let stand undisturbed in a place having as nearly as possible an even temperature of from 75 to 80° F. The acetic fermentation may be started by floating mother or the scum from an older cask on the surface of the mixture by means of thin cork shavings. Carried out in this way and at a suitable temperature (temperatures over 85° F. will retard the process and cause loss of both alcohol and acid) a good honey vinegar can be produced in from four to six months.

SUGGESTIONS FOR THE MANAGEMENT OF THE FARM WOODLOT.[a]

Several of the experiment stations, usually in cooperation with the Forest Service of this Department, are studying certain phases of forestry, more especially from the practical standpoint of the farmer and owner of small areas of woodland. Farmers' holdings are small individually, but in the aggregate they are of tremendous importance to this country. Something like two hundred million acres of land—about one-third of all the forests of the United States—are held in farmers' woodlots. At the same time the country is rapidly using up the supply of standing timber. Lumber prices are rising rapidly, and will surely continue to rise. Since wood for every purpose is sure to become more valuable as time passes, it is worth while for the far-sighted farmer to see to it now that his woodlot is so handled as to yield in future the largest possible supply of this slow-growing crop.

The following suggestions regarding the management of the farm woodlot have been compiled from the publications of the experiment stations and of the Forest Service. The farmer should aim to maintain, and, if possible, improve the value of his woodlot while using it. Too often it deteriorates under use. If he cuts the best trees or those which are easiest to work up, he leaves the "weed trees," as foresters call them—that is, the useless trees, which crowd out and displace good trees—to reproduce. One aim should be to keep up, and, if possible, increase the supply of the kinds of trees which it pays best to grow. While a large part of the product of the woodlot will generally be firewood, it will pay the farmer better to grow as large a product as possible of railroad ties, telegraph and telephone poles, and saw logs.

---

[a] Compiled from Connecticut State Sta. Bul. 154; Massachusetts Sta. Bul. 97; New Hampshire Sta. Bul. 95, and Connecticut Board of Agriculture Rpt. 1905. See also U. S. Dept. Agr., Forest Service Bul. 42, on the woodlot; Farmers' Bul. 173, Primer of Forestry, and work of the Division of Forestry for the Farmer in the Yearbook of the Department of Agriculture for 1898.

A high quality of product will depend not only upon the kinds of trees, but on the size of the trees. A large tree is worth much more proportionately than a small tree, because of the better quality of its product.

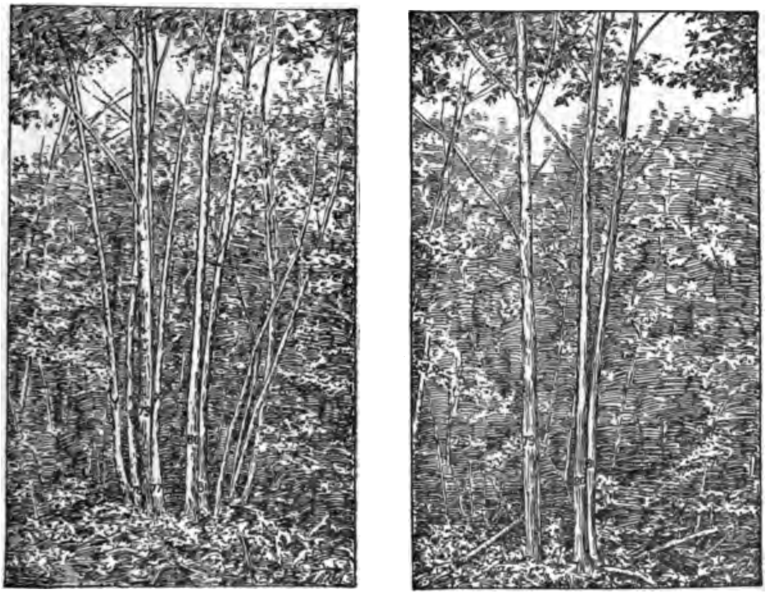
The farmer should always see to it that his land is fully stocked. The average woodlot is understocked. This means that the land is partly idle. If an old pasture is coming up slowly to forest growth, very likely trees can be profitably planted. The farmer will gain by this, although he may not himself live to cut the timber, for land fully stocked with young timber will be salable at a much higher price because of its prospective value. This is already true in many regions. It will be far more generally true as timber increases in value.

The farmer should cut his trees so as to benefit the forest. The branchy, wide-spreading tree, the crooked tree, or the tree of a kind which is not likely to prove salable, is the best for him to cut when he is getting out his supply of firewood. This gives room for the better trees near by to grow, as well as opening the ground for reproduction. Before a tree is cut it should be noted what trees will take advantage of the cut. Care should be taken in cutting to do as little harm to young growth (often regarded as "brush") as possible. This may sacrifice just the trees which should have grown up and set back the next cutting a dozen or fifteen years. Sprouts from the stump grow much more rapidly than trees from seedlings, because they do not have to establish a root system of their own, but are virtually branches of the old tree, which has been pruned back to the ground. Almost all hardwoods (that is, broadly speaking, deciduous trees as distinguished from evergreens) sprout from the stump Consequently where these make up a woodlot by far the largest volume of wood can be secured under a system of sprout or "coppice" management. But the vigor of sprout growth declines as the root systems age; therefore new seedlings are needed in a sprout forest to replace the enfeebled stock.

The farmer should inform himself not only as to what kinds of trees will be most profitable in the long run but also as to what the requirements of the different kinds are. One tree will grow where another will not. It is necessary to know about each kind, and how to get the conditions which will make it grow best. Woodlots to which the principles of forestry have never been applied very commonly offer a good chance for "improvement cuttings." The purpose of such cuttings is to secure needed material, utilize timber which would otherwise go to waste, and make room for other trees to grow. In making improvement cuttings the farmer should look especially for two classes of trees in addition to those already indicated as desirable for removal. These are (1) overmature trees which are beginning to decay and will rapidly lose their value; and (2) ''suppressed'' trees—that is, those whose crowns have been overtopped by their nieghbors so that they can no longer compete for room. It is not worth while, however, to remove suppressed trees if the material which they furnish will not pay for cutting.

Fully stocked stands should be thinned when the trees are large enough to make a thinning pay for itself. The idea in thinning is to remove the weak and inferior trees in order that the better trees may develop more rapidly and perfectly.

The following illustrations, used by A. F. Hawes, State forester of Connecticut, in a recent bulletin of the Connecticut State Station, show some actual examples of thinning chestnut-sprout timber in Connecticut:



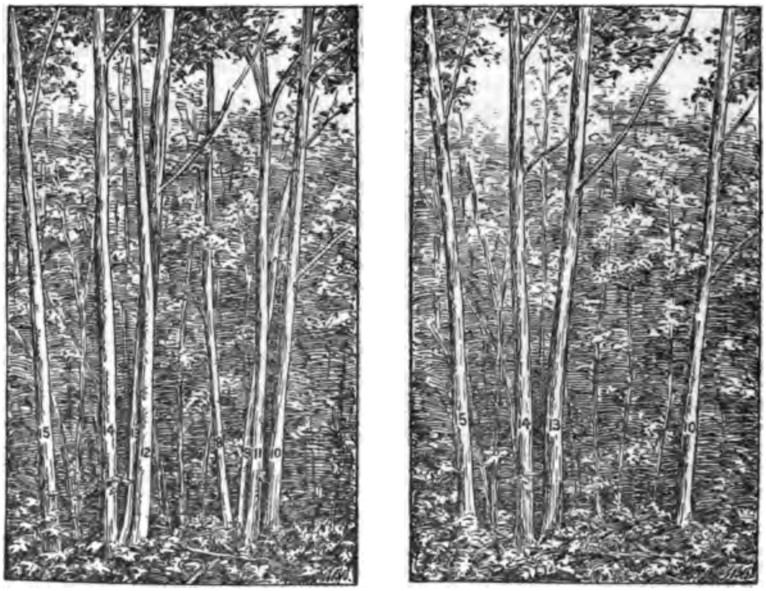
A B

FIG. 1.—A group of chestnut sprouts before (A) and after (B) thinning.

In figure 1, trees 79, 80, and 81 are straight and thrifty, with diameters from 5 to 7 inches and heights from 40 to 43 feet. The crowns of 77 and 78 form a mass of foliage, the removal of which will help 79 and 81. The appearance of this group after thinning is shown in figure 1, B.

In figure 2, poles 10, 13, 14, and 15 are especially promising, being from 5 to 7 inches in diameter and having heights of from 40 to 47 feet. No. 12, although 47 feet high, has a crown too small to supply it with food. Its diameter is only 4.7 inches. By its removal the other three of the group, which are all over 6 inches in diameter, will receive more light and increase their diameter more rapidly. The removal of trees 8 and 9 affect, respectively, 13 and 10. The appearance of this group after thinning is shown in figure 2, B.

In cutting mature timber the chief concern is to secure satisfactory reproduction as soon as possible. The "group method" is generally the best adapted for farm woodlots. Select a spot, or several spots, if one will not supply what is wanted, where the forest crop is ripest—possibly overripe—and clear, with due care for young growth, a hole in the forest, taking care that the diameter of this hole is not more than two or three times the height of the surrounding trees. Gradually widen these holes by cutting in concentric rings about them until the whole area has been cut over.



A B

FIG. 2.—A group of chestnut sprouts before (A) and after (B) thinning.

It should be borne in mind, however, that if in any one year more wood is cut than grows on the whole woodlot in that year, the necessary wood capital is diminished. Where the whole area is cut over before the part cut first has had time to grow to maturity, a period will have to follow during which the woodlot will stop paying dividends.

O

902 Issued February 16, 1907.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 277.

THE USE OF ALCOHOL AND GASOLINE IN FARM ENGINES.

BY

CHARLES EDWARD LUCKE, M. S., Ph. D.
*Assistant Professor of Mechanical Engineering,
Columbia University.*

AND

S. M. WOODWARD, M. S., M. A.
Irrigation Engineer, Office of Experiment Stations.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., January 2, 1907.

SIR: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin of the Department a paper on the use of alcohol and gasoline in farm engines, based in part upon experiments carried out by C. E. Lucke, assistant professor of mechanical engineering, Columbia University, and S. M. Woodward, irrigation engineer of this Office, under the direction of Elwood Mead, Chief of Irrigation and Drainage Investigations of the Office of Experiment Stations, under authority given the Office to investigate "the use of different kinds of power and appliances for irrigation and drainage."

The pumping of water for irrigation and drainage has already assumed great importance, as approximately 600,000 acres of land are irrigated with pumped water. A large part of the unreclaimed arid land can get water in no other way, and as a rule it is so located that fuel of any kind is difficult to get. Alcohol offers in such cases a hope of cheaper fuel, which may mean the reclamation of large areas, since the land irrigated can produce the fuel to maintain its water supply. At present it does not appear that alcohol will produce power as cheaply as gasoline where the latter can be easily obtained, but as a rule the regions where there will be the greatest demand for pumping are the farthest removed from sources of the common fuels, and, on the other hand, they can produce large quantities of crops from which alcohol can be made. This, with the improvements which will undoubtedly be made in alcohol engines, may bring alcohol into use as the distinctive fuel for pumping water for irrigation.

Owing to the fact that there are not on the American market any engines designed especially for alcohol, the experiments so far made have been with alcohol in the gasoline and kerosene engines familiar to the American market.

The purpose of these experiments is twofold: (1) To determine what can be done with alcohol in the existing engines, and (2) to learn what changes in the mechanism of the engines are necessary to secure the highest efficiency in the use of alcohol as a fuel. Since the removal of the tax on denatured alcohol this Office has been flooded with inquiries as to the possibilities of its use. In view of this it has seemed best to publish as a Farmers' Bulletin the essential facts brought out by the experiments made, with some popular matter on the use of gas engines for farm purposes, leaving the details and the more technical results of the tests to be published later, and such publication is therefore recommended.

Respectfully,
A. C. TRUE,
Director.

Hon. JAMES WILSON,
Secretary of Agriculture.

277

THE USE OF ALCOHOL AND GASOLINE IN FARM ENGINES.

SOURCES OF POWER.

There are two great sources of power and an infinitely varied series of mechanical devices and machines for the generation of power. Water power always has been used and probably always will be used so long as the rain falls, but it is insufficient for our present needs or geographically unavailable. The greatest source of power is fuel. Fuels may be divided into two series—those that now exist in the form of natural deposits and those which are being produced continuously. All of the coals, hard and soft, with the lignites and peats, the crude oils and natural gas, exist in the form of deposits; and, while it is true that the decay of vegetable matter may be to-day forming more deposits of the same nature, it is equally true that we are using the present supply faster than the rate of production. The newest fuel for power purposes is alcohol. This is made from the yearly crops of plants. There is in existence no natural deposit of alcohol, but in a sense it may be said to be possible to produce inexhaustible supplies.

It is only within recent time that engineers have known how to build engines that would produce power from alcohol; and still more recent is the further discovery by engineers that this power can be produced at a cost which may permit its general introduction.

By far the largest part of the power now being used comes from steam produced by the use of coal. This is chiefly due to the fact that as a rule whenever it can be used it is cheaper than possible substitutes, although it is partly due to the fact that steam power is better adapted to some classes of work and is older and better known than power generated by the gas engine in its varied forms. In point of present use, water power stands next to steam in importance. This is largely due to the fact that water power is among the earliest in point of development, but more largely to the fact that it has become possible to transform water power into electrical power, which can be transmitted long distances, and so overcome geographical isolation of the sources.

Next in quantity produced stands power generated by the gas engine. This class of engines includes all machines in which the fuel mixed with air is burned or exploded within the working chambers, whether the fuel be gas produced from coal, natural gas, vapors of any of the mineral oils, vegetable or animal oils, or alcohol. The subordinate position occupied by this source of power is due partly to the fact that engineers have only recently discovered, and are to-day discovering, how best to build these machines and adapt them to the work they are to do. Wind and wave power stand at the foot of the list and always will, so far as quantity of power developed is concerned. This is because of the irregularity of the sources of supply and their comparatively feeble nature.

COMPARATIVE COST OF POWER FROM DIFFERENT SOURCES.

The cost of producing power from any of the above sources is made up of a number of items, including interest on the first cost of the installation, depreciation of the apparatus, its insurance, etc., usually called the " fixed charges." To these should be added the costs of fuel, of labor for attendance, and of repairs, as the principal items, and the cost of lubricants, material for cleaning, and a great many other small miscellaneous items, all going to form what are commonly called " operating charges." In all cases where fuel is used its cost is, if not the most important, certainly a very important item. In the case of water power, where the fuel element is zero, the advantage is offset by an interest charge on the cost of installation for dams, pipes, tunnels, shafts, etc. Assuming that power from all of these different sources is equally well adapted to the particular work to be done and equally available, then that system will be selected for any particular case for which the cost of power is least. Leaving out of consideration water power, it is found that the labor costs do not differ nearly so widely for the different systems, nor are they so large, as the fuel cost. Therefore, the great question to-day in power production as regards immediate cost of power and maintenance is this lowering of the fuel cost.

The cost of fuel per unit of power developed depends, first, on the market price of that fuel at the point where it is to be used, and next, but by no means least, on the ability of the machinery to transform the fuel energy into useful work. If all the different kinds of machinery used for power generation could turn into useful work the same proportion of the energy in the fuel, coal would be almost universally used, because of the present low cost of energy in this form.

7

COMPARATIVE COST OF ENERGY IN DIFFERENT FUELS.

The different kinds of fuel contain different amounts of energy per pound—that is to say, they have different heating powers. Heat energy is measured in terms of a technical unit called by English-speaking people the "British thermal unit" (B. T. U.). This unit is the amount of heat that will raise the temperature of 1 pound of water 1 degree on the Fahrenheit thermometer. In comparing, therefore, the value of fuels for power purposes there must be taken into consideration two facts—the market price of the fuel and the amount of heat which will be liberated when it is burned. Anthracite coal in the neighborhood of New York can be bought in small sizes in large quantities for power purposes at about $2.50 per ton. This coal will contain about 12,500 B. T. U. per pound. This is equivalent to about 10,000,000 heat units per dollar. Large sizes, such as egg coal, containing about 14,000 B. T. U. per pound, can be bought in large quantities for about $6.25 per ton, which is equivalent to 4,500,000 B. T. U. per dollar. Other grades of anthracite coal and the various grades and qualities of bituminous coal will lie between these two limits of cost. Illuminating gas in New York costs $1 per 1,000 cubic feet, which is equivalent to about 500,000 heat units per dollar. Natural gas in the Middle States is sold for 10 cents per 1,000 cubic feet and upward. This fuel at the minimum price will furnish about 10,000,000 heat units for a dollar. Crude oil sells in the East at a minimum price of 4 cents per gallon, which is equivalent to about 4,000,000 heat units per dollar. Gasoline sells at a minimum price of 10 cents per gallon, which is equivalent to about 1,200,000 heat units per dollar. Kerosene sells from 10 to 30 cents per gallon, which is equivalent to 1,200,000 and 400,000 heat units per dollar, respectively. Grain alcohol, such as will be freed from tax under the recent legislation, will sell for an unknown price; but for the purpose of comparison, assuming 30 cents per gallon as a minimum, it will give 270,000 heat units per dollar. Gasoline, kerosene, crude oils, and, in fact, all of the distillates have about the same amount of heat per pound; therefore, at the same price per gallon, ignoring the slight difference in density, they would deliver to the consumer about the same amount of heat per dollar, whereas the other liquid fuel, alcohol, if sold at an equal price, would give the consumer only about three-fifths the amount of heat for the same money. From the figures above given it appears that the cost of heat energy contained in the above fuels, at the fair market prices given, varies widely, lying between 200,000 heat units per dollar and 10,000,000 heat units per dollar. It is possible to buy eight times as much energy for a given amount of money in the form of cheap coal as in the form of low-priced gasoline, or twenty-five times as much as in the form of high-priced gasoline or kerosene. This being true, it might seem to a casual observer as rather strange that gasoline should be used at all, and the fact that it is used in competition with fuel of one-eighth to one twenty-fifth its cost shows clearly that either the gasoline engine has some characteristics not possessed by an engine or plant using coal, which makes it able to do things the other can not do, or that more of the heat it contains can be transformed into energy for useful work. Both of these things are true.

THERMAL EFFICIENCY.

As was pointed out before, the different kinds of machinery used to generate power render more or less of the fuel energy into useful work; all systems do not give equal returns for equal amounts of heat supplied. If all the heat energy in fuel were transformed into work with no losses whatever in the mechanism, the machinery would be said to have a thermal efficiency of 100 per cent, and it would require 2,545 heat units per hour to maintain an output of 1 horsepower. If half of the energy in the fuel were lost in the machinery, its thermal efficiency would be said to be 50 per cent, and there would be required 5,090 heat units per hour. If only 1 per cent of the heat energy in the fuel were transformed into useful work, the efficiency of the machinery or power plant would be said to be 1 per cent, and there would be required 254,500 heat units per hour to maintain 1 horsepower.

Steam plants in use represent a great variety of styles or types, but in general it may be said that the more complicated and refined the plant and the larger its size the more efficient it is, because the complication exists only as evidence of an attempt to minimize the losses of heat in the machinery. Similarly the more steadily the plant works at the output for which it was designed the higher the efficiency of the plant, and conversely, the smaller the plant, the simpler the apparatus, or the more intermittently it works, the lower its efficiency. Steam-power plants are built to-day to do every conceivable sort of work, and range in size from 1 horsepower to 100,000 horsepower. For purposes of comparison neither the largest nor the smallest should be used, nor the best performance nor the worst performance of these plants, but a figure representing a fair average for the conditions named should be taken. Large steam plants in their daily work seldom use less than 2 pounds of poor coal per hour for each useful horsepower (known as a brake horsepower), which is equivalent to about 25,000 B. T. U. per hour, and which corresponds to about 10 per cent thermal efficiency. Small steam plants working intermitttently, such as hoisting engines, may use as high as

7 pounds of coal per brake horsepower, which is equivalent to about 100,000 heat units per brake horsepower hour, or 2.5 per cent thermal efficiency. Some plants will do better than the above with proper conditions, and some may do worse, but in general it may be said that the performances of steam plants lie between the limits of 2.5 and 10 per cent thermal efficiency.

Plants consisting of gas producers for transforming coal into gas for use in gas engines have in general a much higher thermal efficiency than steam plants doing the same work. They are, however, not built quite so small as steam plants, the smallest being about 25 horsepower, and in general they have not been built so large, the largest being only a few thousand horsepower. Their efficiency, however, does not vary so much as is the case with steam plants. It may be fair to say that under the same conditions as above outlined these plants will use 1¼ to 2 pounds of coal of fair or poor quality per brake horsepower hour, which gives a thermal efficiency ranging from 18 to 10 per cent. These plants can be made to do much better than this, and perhaps may do worse, although the variation is not nearly so great as for steam plants.

Gas engines operating on natural gas or on illuminating gas from city mains will, on fluctuation of load with the regular work, average about 12,000 heat units per brake horsepower hour, or 20 per cent thermal efficiency. Exploding engines operating on crude oil will average about 25,000 heat units per brake horsepower hour, which is equivalent to about 10 per cent thermal efficiency. Exploding engines using gasoline should operate at a thermal efficiency of about 19 per cent under similar operating conditions.

The efficiency of an alcohol engine may be assumed at this time to be unknown, but as alcohol can be burned in engines designed for gasoline, it may be assumed that such an engine will have with alcohol fuel the same thermal efficiency as with gasoline, to wit, 19 per cent for fair working conditions.

From the above brief discussion of the efficiency of different methods of power generation from different fuels it appears that quite a range is possible, though not so great a range as exists in the case of cost of fuel energy. Efficiency is seen to lie somewhere between 2½ and 20 per cent for all the fuels under working conditions. It is known that actual thermal efficiency under bad conditions may be less than 1 per cent and under the best conditions as high as 40 per cent, but these are rare and unusual cases. The range given is sufficient to indicate that a highly efficient method may make the fuel cost per unit of power less with quite expensive fuel than it would be with cheaper fuel used in a less efficient machine. It is also perfectly clear that without proper information on the efficiency of the machine or the efficiency of the plant it is impossible to tell what the cost of fuel per horsepower hour will be, even though the price of the fuel per ton or per gallon be known. From the figures given on the cost of fuel and a fair average for plant efficiency the cost of fuel per horsepower hour is computed as given in the following tables:

Cost of energy in fuels.

Kind of fuel.	Cost of fuel.	British thermal units (B. T. U.).	Number of B. T. U. bought for $1.
Small anthracite	$2.50 per ton	12,500 per pound	10,000,000
Large anthracite	6.25 per ton	14,000 per pound	4,500,000
Illuminating gas	1.00 per 1,000 cubic feet	550 per cubic foot	550,000
Natural gas	.10 per 1,000 cubic feet	1,000 per cubic foot	10,000,000
Crude oil	.04 per gallon	20,000 per pound	3,650,000
Kerosene	.10 per gallon	20,000 per pound	1,200,000
Do	.30 per gallon	20,000 per pound	400,000
Gasoline	.10 per gallon	20,000 per pound	1,200,000
Do	.30 per gallon	20,000 per pound	400,000
Grain alcohol	.30 per gallon	12,000 per pound	270,000
Do	.40 per gallon	12,000 per pound	200,000

Fuel cost of power.

Fuel and type of plant.	Fuel required per horsepower per hour.	British thermal units required per horsepower hour.	Thermal efficiency.	Cost of fuel.	Cost of fuel per horsepower per hour.
Anthracite coal:			*Per cent.*		*Cents.*
Large steam plant	2 pounds	25,000	10	$2.50 per ton	0.25
Do	2 pounds	25,000	10	6.25 per ton	.57
Small steam plant	7 pounds	100,000	2½	2.50 per ton	1.00
Do	7 pounds	100,000	2½	6.25 per ton	2.20
Producer gas plant	1¼ pounds	14,000	18	2.50 per ton	.14
Do	1¼ pounds	14,000	18	6.25 per ton	.31
Do	2 pounds	25,000	10	2.50 per ton	.25
Do	2 pounds	25,000	10	6.25 per ton	.57
Illuminating gas	24 cubic feet	12,000	20	1.00 per 1,000 cubic feet	2.28
Crude oil	1.4 pints	25,000	10	.04 per gallon	.68
Gasoline	1.1 pints	13,400	19	.15 per gallon	1.70
Do	1.1 pints	13,400	19	.30 per gallon	3.40
Alcohol			[a] 19	.30 per gallon	5.00
Do			[a] 19	.40 per gallon	6.70

[a] Efficiency of alcohol is assumed to be the same as that of gasoline for identical conditions of use.

ADAPTABILITY OF VARIOUS TYPES OF ENGINES.

The foregoing table shows very clearly that the cost for fuel to maintain a brake horsepower for one hour varies widely, and at the prices given the dearest costs nearly 48 times as much as the cheapest. The fact that not everybody uses the fuel giving the cheapest power in point of fuel cost, but that even the most expensive finds a ready market, makes it clear that there must be good reasons. These reasons may be found in local variations in price of fuel, in differences in adaptability of the engines to the work required, and in the fact that the above figures show fuel cost only, whereas there are great differences in the cost of attendance. An elaborate steam plant, to be even fairly efficient, must be continuously operated at fairly heavy load; intermittent working or working at a decreased output makes them wasteful of fuel. Moreover, the apparatus is so complicated, slow to start up, and dangerous to life and property in careless or inexperienced hands that persons must become skilled by years of study and practice before they may be allowed the handling.

The gas engine with its producer can handle to-day the same kind of coal that is used in steam plants, and yet the weight of this apparatus and its lack of flexibility, compared with steam engines, make it unavailable for steamships and locomotives; so it is clear again that adaptability to service is even more important than the cost of fuel. Similarly, gas-producer plants have not yet been successful for sizes smaller than 25 horsepower, and especially unsuccessful have they been so far for intermittent work. For the small sizes the steam plant is also very wasteful of fuel, requires a skilled operator, and is slow in starting; so it is clear why engines burning crude oil, gasoline, kerosene, and other liquid fuels explosively should be used for light work in isolated situations where the work is intermittent and where quick starting and small care in attendance are essential. In this connection it must not be forgotten that a kerosene, gasoline, or crude-oil engine can be started in a few minutes and can even be left running for practically a whole day with only an occasional examination to see that the oil cups are flowing properly and the bearings are not getting hot through being dirty. Steam engines with their boilers, on the contrary, can not be started inside of one or two hours, and all the fuel necessary to raise steam is wasted so far as the work to be done is concerned. Moreover, a steam engine requires continuous feeding of coal and close attention, so that a man must be always near it, having no other duties but its care.

In the natural-gas regions a large number of gas engines are working and in the oil regions a similar number of oil engines and gasoline engines, because the nearness to the supply makes the fuel cheaper than transported fuel, and the exploding engine is more efficient than the steam engine.

It thus appears that in spite of the fact that the fuel element in the cost of power is high for engines burning crude oil, kerosene, and gasoline in comparison with those using coal, at the same time they possess advantages that do not exist in steam plants and gas-producer plants, which give them a very distinct field, as indicated by the following uses to which these engines are being put to-day: Driving boats, automobiles, and railroad motor cars; pumping water for private houses, for farms, for irrigation, and in some cases for municipal service in small towns; compressing air for drilling, hoisting, riveting, etc.; operating small carpenter shops, machine shops, forge shops, and, in fact, any kind of small shop; operating ventilating fans in buildings and in mines; running small factories, su as creameries and butter factories; operating feed-cutting and grinding machinery, corn shredders, and thrashing machines; operating other special machines, such as ice-cream freezers, printing presses, mostly small in size, and making electric light in isolated localities. Not only is this field a real one, but it is a large one, as is shown by the number of these small engines being sold to-day. The exact figures on the sales are not available and it is impossible to secure them because of the unwillingness of manufacturers to tell their business; but when a single manufacturer (as is the case) is selling 425 per day, and there are in the United States alone some 300 manufacturers of importance, there can be no doubt as to the popularity of these machines.

Alcohol at a price unknown now becomes available for use in engines, whose peculiarities are not fully known and whose ability to transform heat into work is correspondingly in question. If the alcohol engine can be shown to have an efficiency as high or higher than other liquid-fuel engines and be similar in type and characteristics, it can do all that they can do, and its field will be the same as their field in spite of fuel costs; but by field is meant the nature of the work rather than the geographical location. It is likely that the alcohol engine will find as favorable a geographical location as the natural-gas engine and the oil engine have near the source of supply and far from the source of competing supply. But should it appear that the alcohol engine can do more or better work than its oil or gasoline competitors, its field will be wider. In any case the position which the alcohol engine may take to-day is no criterion as to its future, because it will operate on a source of energy or fuel supply which, as pointed out, is inexhaustible, whereas the supply of both crude oil and its distillates may ultimately become exhausted.

The determination, then, of the position of the alcohol engine to-day involves a forecast of the future, and should it be shown to be able to compete now it must inevitably reach a stronger and more important industrial position as time goes on. This is the fact that has led governments to take up the question, and among them the United States is the latest.

FIRST USE OF ALCOHOL ENGINES.

About the year 1876 there was placed on the American market the first successful internal-combustion engine using petroleum distillate. This engine was invented by George Brayton. Following the attempt of Brayton to use petroleum distillate came a series of inventions improving this class of engine, lasting for about twenty years, when the modern forms of kerosene, gasoline, and crude-oil engines may be said to have been developed. During this time the subject of alcohol as fuel in engines seems to have been either not thought of at all or not given any attention. The first serious attempt to examine into the possibility of alcohol as a fuel in competition with petroleum and its distillates seems to have been made in the year 1894 in Leipzig, Germany, by Professor Hartman for the Deutschen Landwirtschafts-Gesellschaft. The engine used was built by Grobb, of Leipzig, to operate on kerosene, and used 425 grams of kerosene per hour per brake horsepower, which is equivalent to 0.935 pound, or 1.1 pints, approximately. This indicates for the kerosene a thermal efficiency of 13.6 per cent. When operating on alcohol the engine used about twice as much, or 839 grams, which with this kind of alcohol was equivalent to a thermal efficiency of 12.2 per cent, or a little less than with kerosene. This experiment would seem to indicate that, compared with kerosene, alcohol, as a fuel, offered very little chance for successful competition. In spite of this, however, very vigorous efforts were made to develop an alcohol engine that would be better than this one, and thus was inaugurated a remarkable series of experiments, congresses, and exhibitions with the one end in view—of stimulating the production of the best possible alcohol motor.

The first stimulus was given by the German alcohol distillers, who sought to enlarge their market. They succeeded in interesting the German Government in the question by enlarging on the national significance of having available a source of fuel for power, inexhaustible in quantity, to be produced within the national domain from the yearly crops. Under the double stimulus of government assistance and the desire of the distillers to increase their output, inventors and manufacturers were induced to spend their time and money with a resulting decided improvement in the motor. An engine built by Körting Brothers, of Hanover, fitted with a vaporizer invented by Petreano, tested at the Polytechnic School at Charlottenburg by Professor Slaby showed a consumption of 550 grams of 86.2 per cent alcohol by weight, which is equivalent to 1.21 pounds, or 1.4 pints, or a thermal efficiency of 17.5 per cent. This result showed an advance of nearly 50 per cent in thermal efficiency over the Grobb engine tested a year or so earlier by Professor Hartmann. Following this improvement there resulted a continual development of the alcohol motor, interest in which was kept up by exhibitions in which prizes were offered and by scientific societies. The most important of these are given below.

Exhibition at Halle-on-Saal, Germany, June 13–18, 1901.
Exhibition (national) at Paris, France, November 16–24, 1901.
Exhibition at Berlin, Germany, February 8–16, 1902.
Exhibition (international at Paris, France, May 24–June 1, 1902.
Exhibition at Madrid, Spain, late in the year 1902.
Congress at Montpellier, October 11–21, 1902.
Congress at Paris, France, March 11–17, 1902.
Exhibition (international) at Vienna, Austria, April 2–June 12, 1904.
Exhibition at Rome, Italy, February 6–16, 1904.

Besides the above named, there were many others of lesser importance, all contributing to the rapid development of this class of machine.

The results of this development may be summed up by saying that the thermal efficiency of the motor was raised to something over 30 per cent, which is quite a remarkable showing in comparison with the original figure of 12.2 per cent in 1894. It must be clearly understood, however, in interpreting these figures that they are the best possible attainable at the time reported. They indicate, so far as the fuel costs are concerned, that with a motor specially constructed for alcohol the fuel prices per gallon might be twice as much for alcohol as for petroleum distillate and still give power for less money, assuming that attendance, repairs, lubrication, etc., cost no more in the case of the alcohol engine.

The Office of Experiment Stations of this Department, in connection with its Irrigation and Drainage Investigations, has tested a number of different types of gasoline engines with alcohol and obtained figures which show the comparative consumption of gasoline and alcohol in the same engine. The detailed results of these tests will be published in a technical bulletin, but the general results may be given here. The first tests were made without any particular attempt at obtaining the best adjustment of the engine for each fuel, and showed a consumption of alcohol two to three times as great by weight per horsepower hour as was necessary with gasoline or kerosene. These figures indicate the necessity or desirability of determining the proper conditions of adjustment, because these were found to have a serious influence on the amount of fuel consumed. With care in adjusting the engine so as to secure the most economical use of the alcohol, it was found that, under like conditions, a small engine consumed 1.23 pounds of alcohol to 0.69 pound of gasoline per brake horsepower hour—that is to say, with the best adjustment of the engine for each fuel there was required 1.8 times as much alcohol by weight as gasoline per brake horsepower hour. It was also shown in making this adjustment that it was possible to burn more than twice as much alcohol as stated, by improper adjustments, and still have the engine working in an apparently satisfactory way. The range of excess gasoline which might be burned without interfering seriously with the working of the engine was not so great, being a little less than twice as much as the minimum. These early experiments, therefore, confirmed the early results secured in Germany, to wit, that an engine built for gasoline or kerosene will, when unchanged, require about twice as much alcohol by weight for the same work; but they also indicate something that is not pointed out by the reports sent us from abroad—that is, the great importance of securing the best adjustment of the machine.

To understand why this adjustment of the machine can have such a serious effect and at the same time understand why exploitation and study were successful abroad in raising the efficiency of the alcohol engine from 12.2 to over 30 per cent in five or six years requires a knowledge of technology. The reasons can only become clear to one understanding the mechanism of these engines and to one familiar with the chemistry of the fuels and the physical theories of explosive combustion.

ELEMENTARY ENGINE MECHANISM.

Every exploding engine operating with crude oil or its distillates, or alcohol, must have certain parts, no matter how different engines may vary in other details. These parts are a cylinder in which a sliding plug or piston works back and forth, carrying a pin called the wrist pin, to which is fastened a connecting rod, the other end of which fits in another pin called a crank pin. This crank pin is at one end of an arm called the crank, on the other end of which is the shaft or crank shaft. The piston moves back and forth in the cylinder, but when nearest the cylinder head there is still some space left between the walls, valves, and the piston head. This space is called the clearance, or the explosion chamber, and is the space in which the charge is compressed before it is exploded. In the clearance walls or cylinder head there are two valves in the form of disks, which cover the openings or ports. Through one of the valves an explosive mixture, having certain characteristics to be explained later, is admitted from the source of fuel supply and from the air. Through the other valve the products of combustion after an explosion are expelled. Their duty gives these valves the names of inlet and exhaust valves, respectively. Four strokes are usually required to complete the cycle of events occurring within the cylinder, and to engines requiring these four strokes the name four-stroke cycle or four cycle is given. There are certain other engines with different valve arrangements, which may complete a series of operations in two strokes and these are called two-cycle engines.

The series of operations requiring four strokes is best illustrated by a set of diagrams. In figures 1 to 4 is shown a cylinder with the parts connected to it. On the first stroke or outstroke (fig. 1) the piston is drawn forward either by hand when starting or by the action of fly wheels after the engine is put in motion. This moving forward of the piston is accompanied by an opening of the inlet valve, permitting the explosive mixture to follow the piston and fill the cylinder. The clearance space, before this suction stroke begins, is filled with burnt gases from the previous explosion, so that the amount of mixture drawn in will be equal to the volume displaced by the piston, and this fresh mixture will be mixed with some burnt gases. At the end of suction the inlet valve is closed and compression begins (fig. 2), continuing through the second stroke. During this process both valves are closed and the fresh charge, together with the residue of burnt gases, is squeezed into the clearance space so that it will have as a result a considerable pressure, called the compression pressure, preparatory to exploding. At the end of compression an electric spark explodes the charge, causing the pressure to rise two to four and one-half times the compression pressure. This high pressure in the clearance space will then drive the piston forward.

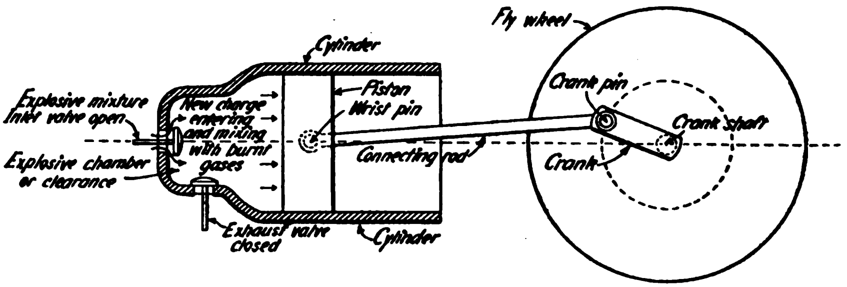


FIG. 1.—Diagram showing mechanism of internal combustion engine—suction stroke.

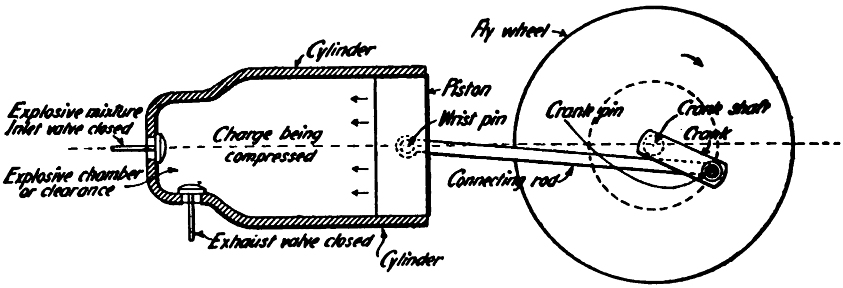


FIG. 2.—Diagram showing mechanism of internal combustion engine—compression stroke.

This stroke, the third or outstroke (fig. 3), is accomplished by the high pressure of the gases filling the explosion chamber and during the progress of the piston the pressure gradually falls, as expansion takes place. During this time both valves are closed, as during the compression. At the end of the expansion (fig. 4) the exhaust valve opens and the piston returns under the influence of the fly wheel, which has been spun around by the explosion, giving the fourth stroke or instroke. The exhaust valve being open for this stroke, most of the burnt gases are expelled, but some are retained in the clearance. After this the fifth stroke begins, which is the same as the first stroke, and subsequently the whole series repeats itself indefinitely and automatically.

While the above operations are usual and the above parts are likewise important, an engine having no more mechanism than is shown would not run. There will be required in addition to what is shown a valve gear, which is a mechanism for opening and closing the valves at the proper time. There must be also some device for making a mixture having the proper characteristics for explosion. This mixture will consist of air and the vapor of the liquid fuel, so that there must be supplied a carbureter, which vaporizes and mixes at the same time, or a vaporizer which vaporizes without mixing. There must also be a mechanism for automatically producing an electric spark at the proper time. This constitutes an igniting gear. The explosions will heat the cylinder so much that a lubricating oil will burn and the piston stick; therefore some cooling device must be supplied, generally in the form of a jacket surrounding the whole cylinder and containing water. If the engine is to do stationary work it must operate at a constant or nearly constant speed, regardless of the amount of work done. This requires a governor. The explosions are very loud; therefore such engines are equipped with a " muffler " to lessen the noise. The rubbing parts, viz, the piston, the main bearings, and the crank shaft, wrist pin, crank pin, valve gear, igniting gear, governor, etc., must all be lubricated to prevent overheating and undue wear, so that a lubrication system is required.

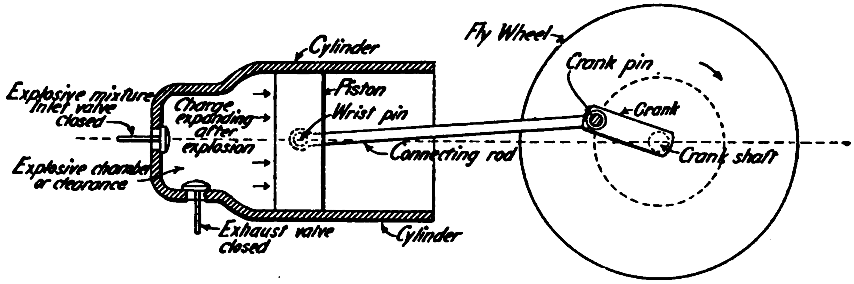


FIG. 3.—Diagram showing mechanism of internal combustion engine—expansion stroke.

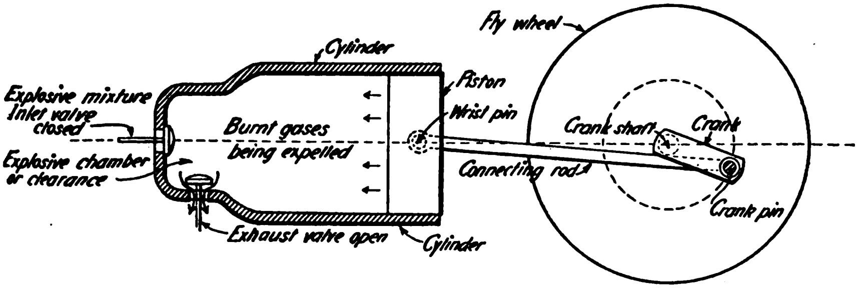


FIG. 4.—Diagram showing mechanism of internal combustion engine—exhaust stroke.

Different makes of engines differ in the above details. All have some provision for performing what is pointed out as necessary, and it is here that inventors and engineers exhibit their skill. All of these engines work as a result of the combustion of the explosive mixture of vapor and air, and a proper understanding of how the various styles of mechanism or changes in detail may affect the engine, requires a preliminary knowledge of their effect upon the explosive mixture.

EXPLOSIVE MIXTURES.

It is easy to understand how an engine may operate without understanding the well-known facts concerning explosive mixtures; but it is impossible to comprehend why engines should differ in fuel consumption or horsepower, good regulation, or any other characteristic without first studying in detail the influence of the mechanism on the composition of the explosive mixture.

Any fuel will burn when there is oxygen present in proper quantity and when the fuel has previously been heated sufficiently. This is true for any kind of combustion, such as the burning of wood, coal, oil in a lamp or cook stove, or gas issuing from an illuminating jet, as well as mixtures in exploding engines. When a fuel is mixed with air containing the right amount of oxygen, or mixed with any solid or liquid containing oxygen in the right amount, then explosive combustion is possible. If such a mixture be ignited at one point by heating it by a flame, a hot plate, or an electric spark, the combustion will travel through the entire mass of its own accord. Otherwise stated, the combustion will be self-propagating. When a mixture has this property of self-propagation of combustion it may be said to be explosive, whether the propagation be fast or slow or whether the explosion be accompanied by noise or not. Gunpowder consists of fuel in the form of carbon or charcoal, together with a little sulphur and a salt, such as a nitrate, containing oxygen. A long train of powder will completely inflame itself if lighted at one point. If the powder be of good quality and pure, the flame will propagate very rapidly. If, however, the powder have some sand or dirt mixed with it, the flame may still propagate, but more slowly, and finally, if there is too much dirt or inactive material present, it will be impossible to ignite the whole mass by self-propagation. Engine mixtures do not consist of solid fuel like gunpowder with oxygen in the nitrate form, but on the contrary consist always of gaseous fuel or liquid fuel vapor mixed with air. The combustion of gaseous mixtures is very much the same in nature as the combustion of gunpowder, which is not thought of as a mixture but which really is. If a mass of explosive mixture be contained in a vessel or in a glass tube and be ignited at one end of the tube, the eye can distinctly follow a flame traveling through the tube. The entire tube does not show a flame at any one time, but instead it will be found that the flame is in the form of a disc or cap and that this flame cap travels through the tube, the flame cap being blue in color, with slight variations. When it has traveled past a certain point all the mixture between that point and the place where the combustion started is burnt, and all the mixture beyond the flame cap is still unburned.

LIMITS OF PROPORTION.

When the air and vapor are mixed in just the proportion known to be chemically correct the mixture is explosive. If it contains a small excess of fuel—that is to say, a little more fuel than the air present will burn—it may still be explosive, but much excess of fuel will cause it to cease being explosive. There is thus a high limit to the explosive proportions. Similarly, if there is present a little more air than is necessary to burn the vapor, the mixture will be explosive, but much excess of air will make it nonexplosive; and therefore there is a low limit to the proportions for explosive combustion. Mixtures of all proportions between the high and low limits will burn explosively. If to any explosive mixture there is added some inactive gas, such as nitrogen, carbonic-acid gas, steam, or the products of combustion of a previous explosion, the mixture will not burn so well as without this neutral addition. If there is much neutral added, it will be found that the mixture is no longer explosive, although the proportions of air to vapor are quite right chemically. Thus there is a third limit by neutral dilution. Therefore, for a mixture to be explosive it must contain air and vapor, though not too much air, gas, or neutral. A mixture which by reason of its proportions is beyond the range of explosive combustion may be rendered explosive by compressing it without in any way changing the proportions of air to gas or the amount of neutral present, and the more it is compressed the more rapid will this self-propagated combustion be. Temperature has a similar effect on the limiting proportions.

TEMPERATURE OF IGNITION.

By careful experimenting in scientific laboratories it has been found that explosive mixtures of different fuels do not all ignite at the same temperature; that some, for instance, must be heated to a higher temperature than others to start combustion. It has been found also that the temperature of ignition is lower for any given fuel when there is just a little excess of fuel in the mixture. If the mixture contain much excess of fuel, it must be heated to a higher temperature before ignition can be started. The temperature of ignition for any mixture will not be raised by adding inactive gas or by changing properties, but it may take a longer time to ignite when weak.

It has been found that raising the pressure or raising the temperature of the mass before attempting to ignite it will cause it to apparently ignite more easily. The time necessary to start ignition is lessened if the mixture be confined so that it can not circulate. It appears that a mass of mixture being heated at one point in an attempt to ignite it acts very much like the air in a room when the room contains a radiator for heating. The mixture near the radiator rises before becoming very hot, and it takes some time before any part of the mixture can be raised to the temperature sufficient to ignite it unless the circulation be suppressed. While no exact figures are available for the temperature of ignition for the mixtures used in these exploding liquid fuel engines, they can be placed in the following order:

Kerosene mixtures have the lowest temperature of ignition.
Gasoline comes next but is quite close to kerosene.
Alcohol mixtures have the highest temperature of ignition and are quite far removed from kerosene and gasoline.

RATE OF PROPAGATION.

The velocity with which the flame cap travels through the mass of mixture is termed the "rate of propagation," and this is sometimes very high and sometimes very low. Mixtures containing a certain small excess of fuel over what seems to be chemically correct burn faster than any other mixtures of that fuel. With much excess of fuel, much excess of air, or much neutral gas, the rate of propagation becomes lower, so that mixtures burn slower the further they depart from the proper chemical proportions (with the exception noted) or the more inactive or neutral gas they contain. The nature of the fuel has an influence on the rate of propagation and for our purpose it is only necessary to cite kerosene, gasoline, and alcohol mixtures. Kerosene mixtures burn fastest, and so have the higher rate of propagation. Next come gasoline mixtures and lastly alcohol, with the lowest rate of propagation, assuming, of course, always the correct mixtures in each case. The higher the pressure of the mixture before ignition the faster it will burn, so that the rate of propagation depends upon the pressure. Similarly, the hotter the mixture when ignited the faster it will burn, so that increase of temperature makes it burn faster or raises the rate of propagation. The shape of the chamber containing the mixture has a very decided effect on the rate of propagation. It was found by observing mixtures burning in glass tubes that, when very small tubes were used, the rate of propagation became perceptibly retarded, and when extremely small tubes were used the rate of propagation was zero; that is to say, the tube can be made so small that the flame will not propagate itself through the tube at all. This is because with very small tubes the heat can be conducted away from the flame faster than the flame liberates it, with the effect that combustion ceases simply by cooling, just as water quenches a fire. If, in a tube so small as to prevent propagation, the mixture be compressed, it will liberate heat faster by reason of its greater density, and self-propagation will then be possible. It appears, then, that affecting this rate of propagation there is a whole series of influences, some tending to make it less, others more, with the consequent result of making it difficult to predict what will happen in a new case. A knowledge, however, of these causes of increase and decrease is essential in the interpretation of engine results, because the rate at which pressure rises in the cylinder after explosion depends upon the relation between the rate of propagation in the mixture and the piston speed of the engine. The motion of the piston outward tends to lower the pressure, while combustion by self-propagation tends to raise it. If the piston speed be small in proportion to the rate of propagation the pressure will rise in the cylinder rapidly. If, however, the piston speed be great and the rate of propagation small, the pressure may not rise at all in the cylinder or it may even fall during the explosion.

Aside from the mere question of average velocity of propagation, there is another question of great importance, and that is the mode of propagation. It has been shown by the work of the French scientists that there are three modes of propagation, or that the wave cap travels through the mass in three ways, each producing different effects and all of them influencing the performance of an engine. If the mass be free to expand while burning, the flame will communicate its heat to the next layer of mixtures and so ignite it. Thus by successive heatings of layers the flame would propagate "uniformly." The expansion of the burnt gas, however, if explosion takes place in a chamber confining the mixture, under the influence of the heat generated by the combustion, seems to start a pressure wave through the mass similar to a sound wave, and the flame cap can be seen to oscillate in its advance. This is said to be an "undulatory" movement, which is the second mode of propagation. If by any series of circumstances a number of waves of this kind should be set up in the mixture so that the crests of one wave matched the hollows of another, the waves would be eliminated. If, on the contrary, the crests of the first be superimposed on the crests of the second, third, etc., the waves would be synchronized and produce momentary high pressure, localized at the point representing the wave crest, thus giving rise to the third mode of propagation, the explosive wave. In any case a wave in the mass that may synchronize with waves of combustion will exaggerate the possibility of producing the explosive wave. Agitation of the mass, such as is produced by a jet impinging into the main mass, will do this, and so will a wave of piston compression. This is a matter of very considerable importance in engines, for, if the exhaust chamber be not of the right form, there may be pockets or isolated masses of mixture so placed that ignition starting in one will raise the pressure in that, causing a flow of gases toward the other with a corresponding agitation and synchronizing of waves, resulting in the explosive wave. An explosive wave gives rise to pressures in this way very much in excess of the pressure due merely to the heat liberated, reaching 600 pounds per square inch in the engine cylinder. If the ignition be early; that is to say, if ignition be started while the piston is still compressing gas, there will invariably result similar explosive waves, straining the engine without any useful effect.

PRESSURE DUE TO EXPLOSION.

The pressure after exploding the charge will depend upon the amount of heat liberated and upon the weight of gas present. The amount of heat liberated by the explosion of the mixture of vapor and air will depend upon what fuel it is, whether kerosene, gasoline, or alcohol; the proportions of vapor to air; the amount of burnt gases left in the clearance, and the extent to which the charge has been heated on entering the cylinder during the suction stroke, and, finally, upon the compression pressure before ignition. It is easy to calculate this temperature rise on assumed values for these conditions, but it is just as easy to prove these assumptions wrong, so that computations of this kind are of no great value. Designers must, however, design an engine to resist these pressures, and so must have experimental values of this pressure. They are also valuable to experimenters in interpreting the performance of the engine by comparing the highest pressure observed in some case with the normal. If the normally high pressure is not attained, it has been due to an improper point of ignition, a loss in charge, or a weak mixture. The experimenter can also distinguish between normal pressure due to the heat liberated and abnormal ones due to explosive waves, which are destructive to the engine bearings and metal parts, but not useful for producing work.

LIQUID FUELS.

The liquid fuels available for use in exploding engines—that is to say, for vaporizing and mixing with air in a properly constructed mechanism—have quite different characteristics. With respect to their source they can be divided into two classes: The first, crude petroleum and its distillates, which have some characteristics in common; and the second, alcohol, which is quite different from any of the petroleum distillates in all of its characteristics. When crude oil is boiled or refined, vapors are evolved which may be condensed. These condensed vapors are called "distillates." In a refinery the temperature of the vapor coming off is measured and the distillates collected either between two limits of temperature or two densities, for as the boiling proceeds the temperature of the liquid and vapor continually rises and the density of the distillates also continuously rises. The first distillates are light and the last heavy. The last distillates constitute lubricating oils; the first and intermediate distillates constitute gasoline, naphthas, kerosene, etc., available for revaporization for use in exploding engines. These distillates are not simple fuels, but are mixtures of different chemical composition, always containing carbon and hydrogen. They comprise all the material that goes over in the boiling between two limiting densities, the mixture having a sort of average density.

There is not a good agreement between the character of the materials designated gasoline, kerosene, etc., and the temperature of distillation and densities employed in different places, so that such names seem to have more commercial significance than scientific value. The following table shows one set of values that is probably as good as any densities reported, they being compared with water and given in Baume's hydrometer scale at 59° F.:

Definition of petroleum distillates.

Name.	Boiling point.	Specific gravity.	Density.
	° F.		*° Baumé.*
Petroleum ether	104–158	0.650–0.660	85–80
Gasoline	158–176	.660– .670	80–78
Naphtha C	176–212	.670– .707	78–68
Naphtha B	212–248	.707– .722	68–64
Naphtha A	248–302	.722– .737	64–60
Kerosene	302–572	.753– .864	56–32
Lubricating oil	572 up	.864– .960	32–15

Gasoline is far different from a simple substance which would have a fixed boiling point, and therefore theoretical calculations on the heat of combustion, air necessary, and conditions for vaporizing or carbureting air are of little value. On the other hand, alcohol is a simple substance, or, more properly, there are many alcohols each of which is a simple substance; but they are not so used in an engine. The alcohol which it is proposed to manufacture for industrial uses under the recent law is ethyl alcohol having a definite chemical composition C_2H_5OH. This material is seldom, if ever, obtained pure, it being generally diluted with water and containing other alcohols when used for engines. The alcohol present is in an impure condition. Thus 90 per cent alcohol means alcohol and water mixed so that there is 90 per cent of alcohol by volume present. The density of the alcohol depends upon the amount of water present, of course, and upon the temperature as well, as it varies considerably with temperature. The Smithsonian tables of the density of alcohol with temperature are given below in part with a computation by which the percentage of alcohol by weight or volume can be determined when the density and temperature of the mixture are known:

Smithsonian table of specific gravities of ethyl alcohol.

Specific gravity at 60° F. compared with water at 60° F.	Percentage of alcohol—		Specific gravity at 60° F. compared with water at 60° F.	Percentage of alcohol—	
	By weight.	By volume.		By weight.	By volume.
0.834	85.8	90.0	0.822	90.4	93.4
.833	86.2	90.3	.821	90.8	93.7
.832	86.6	90.6	.820	91.1	94.0
.831	87.0	90.9	.819	91.5	94.2
.830	87.4	91.2	.818	91.9	94.5
.829	87.7	91.5	.817	92.2	94.8
.828	88.1	91.8	.816	92.6	95.0
.827	88.5	92.1	.815	93.0	95.3
.826	88.9	92.3	.814	93.3	95.5
.825	89.3	92.6	.813	93.7	95.8
.824	89.6	92.9	.812	94.0	96.0
.823	90.0	93.2			

For the range of percentage contained in the above table, the correction for temperatures different from 60° F. should be made as follows:

If the density is measured at a temperature above 60°, 0.0005 should be added to the measured density for each degree which the temperature at the time of the measurement differs from 60°. When the temperature at the time of measurement is below 60°, the same correction should be subtracted from the measured density. The corrected density should then be used in the table for finding the true percentage of alcohol.

The percentage of alcohol found in a sample is always likely to be greater when determined chemically than when determined by the hydrometer, because the presence of impurities in the way of solids dissolved in the alcohol or as any of the series of higher alcohols tends to make the specific gravity of the sample greater, and hence make it indicate too low a percentage of alcohol.

Although pure alcohol is, as was shown above, a simple chemical substance, and so permits of computations on the heat of combustion, the amount of air necessary for its proper combustion, the amount of heat to vaporize it, the proper air temperature for carburetion, or anything else that might be desired in connection with its performance in an engine, yet in actual engines this pure alcohol is never used. The revenue laws permit the tax-free use of only denatured alcohol, that is to say, a fuel consisting principally of ethyl alcohol, but with various substances added to it to render it unfit for drinking, and which may have little or much effect upon its value as an engine fuel. In the United States the substances to be added are at least 10 parts of methyl alcohol to 100 parts of 90 per cent ethyl alcohol by volume, in addition to one-half of 1 part benzine. Even this small addition makes it difficult, if not impossible, to make accurate calculations concerning what the mixed fuel will do in an engine. In Europe, during all these years of development, many hundreds of tests have been made with all sorts and conditions of fuel mixtures, some of them with alcohol which is free of denaturants, some with denatured alcohol, and some with purely experimental mixtures. Every different fuel element and every different fuel mixture will have characteristics when used in an engine, so that in comparing these engine results it is clearly necessary to have some knowledge of the nature of the fuel mixtures used.

HEAT OF COMBUSTION.

One of the most important things to know concerning a fuel is the amount of heat it will liberate when burned, or its heat of combustion, for by this the weight of fuel burned per horsepower-hour can be transformed to thermal efficiency. This is determined practically by burning the fuel in a very accurate instrument called a calorimeter, so arranged that all of the heat will warm up water so that the amount of heat liberated may be determined by the temperature rise of this water. The heat of combustion, thus determined for the gasoline which we used in our tests, was found to be 21,100 B. T. U. per pound of gasoline. It is known that the heat of combustion of gasoline is not very different from that for the crude oil or any of the other distillates, and in common practice it is usual to take this value as 20,000 B. T. U. per pound of oil when other more accurate information is lacking. The alcohol which we used in our tests, 94 per cent by volume, had a heat of combustion as determined by the calorimeter of 11,900 B. T. U. per pound, which is just a little more than half that of the gasoline. The heat of combustion as determined by the calorimeter does not fairly represent the amount of heat set free in the engine cylinder, because when the fuel contains any hydrogen—and all of these fuels do—that hydrogen will form steam on combustion, which will condense to water and add its latent heat of condensation to the true heat of combustion. The heat of combustion obtained when the products are condensed, as in the calorimeter, is termed the high value; that obtained by subtracting from this high value the latent heat of condensation of such water as is formed is termed the low value. In reporting a calorific power for any of the oils or alcohol it must be clearly known whether the value is high or low, as they are appreciably different. Especially important is this when it is known that only the low value is set free in exploding engines, because the exhaust gases are always hot enough to prevent condensation of steam. These fuels contain carbon and hydrogen in various proportions and the alcohol contains, in addition, some oxygen. Knowing the heat of combustion and the elements, it would seem possible to calculate the heat of combustion of compounds of these elements, and various formulas have been proposed for this purpose which are used in some cases by European experimenters in reporting their results. It is interesting to note in this connection that the heat of combustion determined by such a formula from its ultimate analysis seldom gives values that agree with the calorimeter. This is because of certain assumptions made on the molecular constitution of the elements shown to be present. Thus, when hydrogen and oxygen are present in water proportions it is assumed that the group can not give any further heat of combustion, and further, that there is no heat absorbed to separate the group from the other molecules as heat of dissociation. This assumption vitiates the results, but for any given fuels a constant can be determined in the nature of a correction to the calculation to make the results agree with the calorimeter, which it is possible to apply with fair accuracy to similar fuels.

AIR NECESSARY FOR COMBUSTION.

When a fuel has a definite chemical composition, the air necessary for combustion can be exactly determined; otherwise it must be an assumption. This calculation can be made, therefore, for ethyl alcohol or for methyl alcohol, but it is difficult, if not impossible, for a denatured alcohol or for gasoline or kerosene.

In an actual engine the amount of air is proportioned to the amount of vapor, not by any exact measurement of either, but by experimental trial, to secure either the best results in maximum power or minimum fuel consumption, but in this case the experimenter has no knowledge of the fuel supplied but unburned. As a check upon this adjustment, it has been the practice in the European tests, especially those of Sorel, to analyze the exhaust gases with a view to determining the amount of air supplied by the chemical composition of the exhaust. An engineer operating the engine, however, has no means for determining results such as this, and, in fact, cares very little just what quantity of air is being supplied so long as it is clear that no fuel is passing away unburned or so long as the engine is doing the proper amount of work with the minimum of fuel.

VAPORIZATION OF FUEL.

Before any liquid fuel is available for use in an exploding engine it must be vaporized, and this vapor must be mixed with air in the proper proportions—that is, as near the chemical proportions as may be possible. Thus the preparation of the fuel for use in an exploding engine involves three steps. First, vaporization; second, mixing with air; third, adjustment of proportions. The devices used in the engines to accomplish these things show the widest variation of detail design. In some of these devices the fuel is boiled in a chamber which is then known as a vaporizer, and the vapor is allowed to flow into a stream of air entering the engine, the amount of vapor being regulated by a valve, just as is done in a gas engine. During the process of vaporization the air is not in contact with the vapor as it forms. In the next type of vaporizer the fuel is dropped on a hot plate, over which the air flows on its way to the engine, and the proportions are fixed by the rate of air flow or by the rate at which the fuel is supplied to the hot plate or by the temperature of the plate. When the fuel will vaporize at a low temperature below that of atmospheric air, it is not necessary to have any heated plate, and the fuel may be dropped directly into the entering stream of air, the proportions being adjusted by the opening of a small valve. Kerosene requires a plate or chamber quite considerably heated to completely vaporize it, as the boiling point is high. Gasoline requires nothing of this sort, as it easily vaporizes at atmospheric temperatures. Alcohol lies between these two fuels in this respect. It requires temperatures higher than the usual atmospheric temperatures, but not so high as those necessary for kerosene.

A device for preparing the mixtures in these engines, which performs three functions—vaporizing, mixing, and proportioning—is called a carbureter. Carbureters are universally used for gasoline and similar easily vaporized substances. Vaporizers in one form or another are almost universally used for kerosene, although some kerosene carbureters have been devised differing from the gasoline carbureter chiefly by the addition of a heating part. Alcohol is used in both of these devices—that is to say, alcohol carbureters are common and so are alcohol vaporizers, but the carbureters more common than the vaporizers. An alcohol carbureter may differ not at all from a gasoline carbureter, but by reason of the high temperature of vaporization of the alcohol some method of heating either the air or the mixture is necessary to insure complete vaporization, and the more water present the higher the necessary temperature. In order that the above distinction may be clear and variations in the detail design for accomplishing the same purpose may be set forth, descriptions of a few typical devices are given.

One common form of pure vaporizer in use in the West is a retort, of the class involving the dropping of oil on a hot plate. This is shown in figures 5 and 6. The exhaust from the main engine enters the retort at the port (A). The hot exhaust gases heat a central drum, around which the generating wheel revolves. The generating wheel (C) is a hollow wheel or drum, containing channels or buckets on the periphery. This wheel is driven by a belt from the main engine around a driving pulley (fig. 6, G), transmitting power through a worm and gear to the driving spindle (I). The driving spindle is attached to the generating wheel, which revolves about one-half turn a minute. The heat radiating from the heated drum is intercepted by the generating wheel and utilized in transforming the oil into gas as it is fed into the channels of the generating wheel through the oil port (fig. 5, F). As the oil is fed into the channels through the oil port it is carried up and over the top of the wheel, giving up its volatile parts by reason of the heat received from the wheel. The nonvolatile portion of the oil, or the residuum, remains in the channels until they reach the bottom, where the residuum drops into a reservoir and is automatically drained off through the residue port by means of a pipe with a drop of 8 inches or more below the retort, having a horizontal check valve on the end. The check valve is for the purpose of keeping the residuum from being drawn into the engine cylinder. The exhaust gases are carried away from the retort

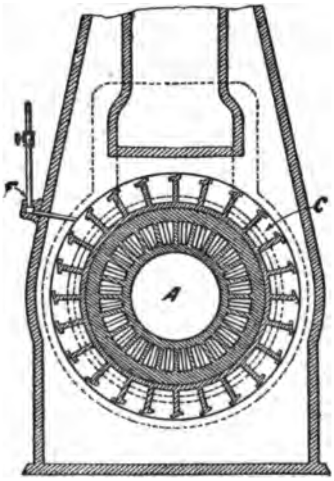


FIG. 5.—Section of retort vaporizer.

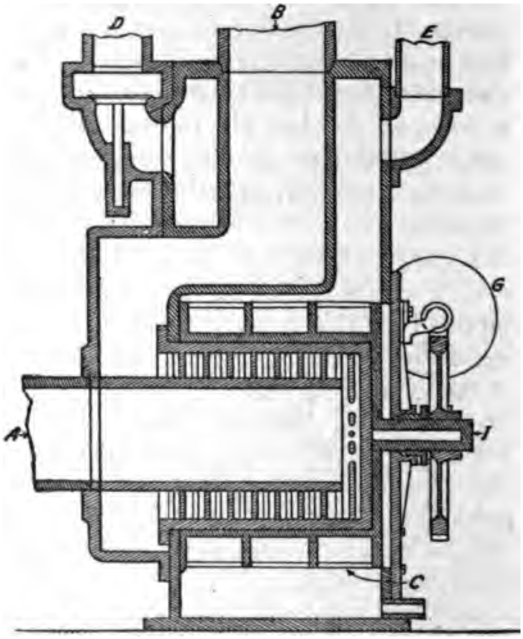


FIG. 6.—Section of retort vaporizer.

by means of a pipe screwed into the flange attached to the exhaust outlet (fig. 6, B). As the gas arises from the wheel to the gas chamber it circulates around a hot exhaust pipe, thus being superheated. It is immediately drawn into the main engine cylinder by the suction of the engine, through a connection of pipe and fittings from the gas port (fig. 6, D), to the inlet to the engine cylinder, where it is ignited by whatever means may be used for that purpose. Air is also drawn by the engine suction into and through the retort case, entering at the air-inlet port (fig. 6, E). In some cases the air-inlet pipe, connected to this port, runs about 2 feet and then turns down again. This is recommended to prevent gas from escaping through the air inlet between suctions.

There are no devices on the American market of the kind that specifically boils the fuel in a separate chamber. A device of this kind would have certain advantages over that of the simple hot-plate type for the following reasons: If the plate on which the oil is dropped gets too hot, the fuel will decompose, in addition to vaporizing, and leave on the plate a black sooty residue. This is because these fuels are very sensitive to decomposing from overheating. If the plates are not hot enough, the fuel will be only partly vaporized, and good fuel will be thrown away as residue. When the heating is to be accomplished by the exhaust gases, not only must a lamp be supplied for initial heating, which takes a long time with such a mixing device as this, but further, and more important, the temperature of the vaporizing plates is very difficult if not impossible to regulate. On fluctuating load, therefore, where the engine requires more or less vapor from time to time the hot-plate vaporizer would sometimes be decomposing fuel from excess heat, at other times only partly vaporizing it, and in any case proportions of air to vapor will be sure to be irregular, so that in the mixture there will sometimes be an excess of vapor and sometimes an excess of air. Such a hot-plate vaporizer, therefore, is adapted only to those oils that can not be otherwise treated in carbureters. For this reason retorts of this kind are almost solely confined to engines which use the crude oils.

There is on the American market a class of engines having a vaporizer which forms part of the cylinder head and which is heated by the explosions taking place inside the exploding chamber. Otherwise stated these vaporizers are themselves exploding chambers. One of these is shown in figure 7. On this figure, A is the vaporizer proper. Under it is seen a lamp (B) with a burner (C), and, to prevent undue radiation in heating, the burner and vaporizer are surrounded by a casing (D). This vaporizer is bolted to the cylinder head (E) and contains on its inner end a lip projecting into the exploding chamber. A little pump injects a small stream of oil at every stroke and drops it on this lip from the pipe (F). This lip is very hot from previous explosions and from the lamp, which, by the way, is turned off when the engine begins work. The compression stroke of the piston forces the air in the cylinder over the lip and through the neck into the vaporizer bulb, thus mixing more or less completely the vapor which formed on the lip with the air that is forced over the lip into the bulb. Such hot-bulb vaporizers as this will work with practically all of the fuels—crude oils, gasoline, kerosene, and alcohol—with proper adjustments of the pump and of the temperature of the bulb. These bulbs perform another duty besides vaporizing and mixing. Their high temperature, that of a red heat when in operation, is sufficient to ignite the mixture when the compression is high enough, thus eliminating any necessity for electric igniters. In engines fitted with this type of vaporizer no mixture enters the cylinder at all; nothing but air passes through the inlet valve. Oil is pumped in, drops on the vaporizer, there meets the air, with which a more or less complete mixture is formed, the mixture is compressed, and by the compression heated and ignited. This type of vaporizer igniter has, besides the above advantages, certain disadvantages: (1) The vapor is but imperfectly mixed in the air; (2) the exceedingly high temperature in the vaporizer, which it is impossible to avoid, will more than vaporize some of the fuel, decomposing it and depositing soot if the fuel be hydrocarbon; and (3) another bad feature in the use of such a vaporizer is to be found in the fact that some air remains between the piston head and the bulb, and this is inactive, no fuel being burnt, the only active part being that which enters the bulb. Engines fitted with vaporizers of this kind, therefore, can not do as much work for the same size cylinder as an engine in which the entire mass of gases in the clearance is active explosive mixture. Furthermore, these engines will always use more fuel than is necessary because of the incomplete mixing of fuel vapor and air and the partial decomposition of some of the fuel.

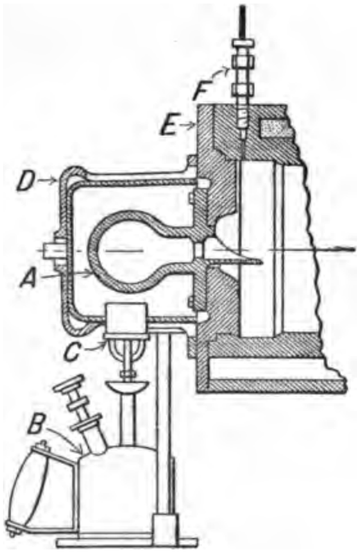


FIG. 7.—Section of hot-bulb vaporizer.

Another vaporizer of the hot-plate sort, intended particularly for ıol, illustrated in figure 8, is known as the Brouhot, a French Exhaust gas enters at the bottom, as shown by the arrow and ring on the cut, and rises through the iron chamber, which is ıgated to increase the surface without making the apparatus too y. Alcohol is admitted near the bottom of these ribs or corru- ons and flows upward on the side opposite to that heated by the ust gases. The regulating valve is attached to permit some ust gases to pass around the heating chamber and so vary its erature, but the regulation of temperature must be done by hand. or rising from the surface of the alco- in the top of the chamber meets air, :h passes first through the regulating e intended for the adjustment of pro- ions. The corrugations are such as to ı a screw thread or a helix passage and exhaust entering first at the bottom es directly to the top of the chamber downward in the helical groove to the om, so that the top of the helix will be hottest part. Alcohol enters the bot- of the opposite helix, flows upward vaporizes somewhere in its upward se, discharging into the air current at ıot top of the helix as superheated alco- vapor. This vaporizer is, therefore, of oiling type, but the boiling takes place ıe surface of the liquid which is at the sure in the suction pipe, and the rate of ng is regulated by hand by admitting › or less exhaust gases to the vaporiz- helix.

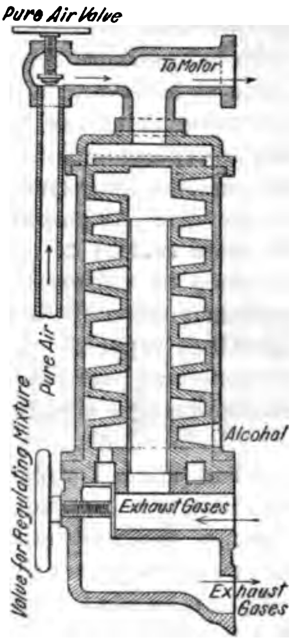


FIG. 8.—Section of Brouhot vaporizer.

ıparate vaporizers as distinguished ı carbureters are essential for kerosene common for alcohol. They have been described at this point ıse the principles of their operation are simpler than those of car- ters and they are less numerous and less representative.

ırburetion is a process distinctly different from boiling. Air take up the vapor of a liquid just as it takes up the vapor of r, even when the temperature of the liquid or the temperature of ıir is very considerably less than the boiling point of the liquid. ıort, air may take up some vapor at any temperature whatever, it is not necessary that the liquid be brought to the boiling point. amount of vapor which air can take up by simply coming in con- with the liquid depends upon the vapor tension of the liquid and pressure of the air. The air may be assumed to be always at

n

atmospheric pressure, for the pressure in the suction pipe of an engine is but little less than that of the atmosphere. The amount of vapor that can be taken up from the liquid surface can be calculated quite exactly if the air is left in contact with the liquid long enough and if the liquid is a simple substance having a definite chemical composition and a definite vapor tension. The method is exactly the same as that used to compute the humidity of the atmosphere. Since gasoline is not a simple substance, such a calculation is impossible, but it is known by the practical operation of engines having carbureters that at ordinary atmospheric temperatures the air is quite hot enough to vaporize enough gasoline to make a proper explosive mixture and is in fact capable of absorbing quite a considerable excess of gasoline before it becomes saturated with gasoline vapor. There is, however, no difficulty whatever from the standpoint of air saturation in giving to the air sufficient gasoline vapor to make a proper explosive mixture for engines if the air be left in contact with the gasoline long enough, or if, in addition, the contact be of the proper sort. As gasoline consists of substances of different volatility, the mere contact of air with the surface of the liquid may not be sufficient to uniformly vaporize the mixture. The more volatile parts may come off first and there may be a residue which it will be difficult to vaporize. This difficulty was met with in the earlier carbureters and overcome in a way that will be explained presently. Alcohol being a simple substance, with a definite vapor tension, it is possible to calculate at what temperature dry air must be to contain sufficient alcohol vapor. If the air have any temperature higher than this, it is capable of carrying more alcohol than is necessary for a proper explosive mixture or capable of absorbing the amount of vapor necessary in a shorter time.

By a somewhat lengthy calculation it may be shown that dry air at a temperature of 72° F., when saturated with alcohol vapor, has just enough of the vapor to form the theoretically best mixture for perfect combustion. If the air be moist, or the alcohol contain water, or the time allowed for vaporization be too brief, the temperature of the air must be higher than 72° F. to form a proper explosive mixture.

As the engine does not use pure alcohol of this sort, but rather mixtures known under the general name of denatured alcohol, the corresponding temperature necessary to secure this proper vaporization will be different from that just given, but just how different can not be stated. However, it is certain that air at any temperature will take up some vapor of alcohol and that the higher the temperature of the air the quicker it will take up the necessary amount for the best explosive mixture. In the case of incomplete vaporization some of the fuel may be carried along as spray, which may be vaporized in the cylinder on the compression stroke or may not, but if not then it certainly will be after the explosion of the rest. It would seem desirable, therefore, to quite considerably heat the air supplied to an alcohol carbureter; yet indefinite heating of the air will bring about a bad effect on the engine, because it will make the charge hotter at the end of compression, or, in other words, decrease the weight of the charge in the cylinder. The horsepower of the engine, other things being equal, will be decreased in direct proportion as the density of the charge is lowered by this heating, so that, on the one hand, heating of the air is good for complete vaporization, but bad, if carried to excess, in reduction of power.

The earliest forms of carbureters operated on the principle of simple contact between the gasoline and air. One of the most successful of this type is that used by Gottlieb Daimler, to whom all credit should be given for the developing of this type of carbureter and by it the high-speed liquid-fuel engine. Daimler's surface-contact carbureter is shown in figure 9. It consists of a tank fitted with a central tube and float. In the bottom of the tank is the gasoline, on its surface the float, and in the float a hole through which the gasoline may rise to a certain height. Air flows down a central pipe and strikes the surface of the gasoline at the top of the hole in the float, picking up vapor, the mixture flowing directly to the engine. The pipe down which the air flows is kept by the float to a constant amount of submersion, so that the air must bubble through the gasoline to a certain depth. The chief objections to this carbu-

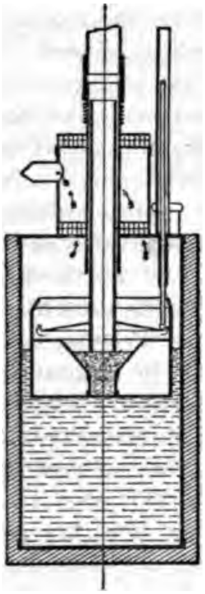


FIG. 9.—Section of Daimler carbureter.

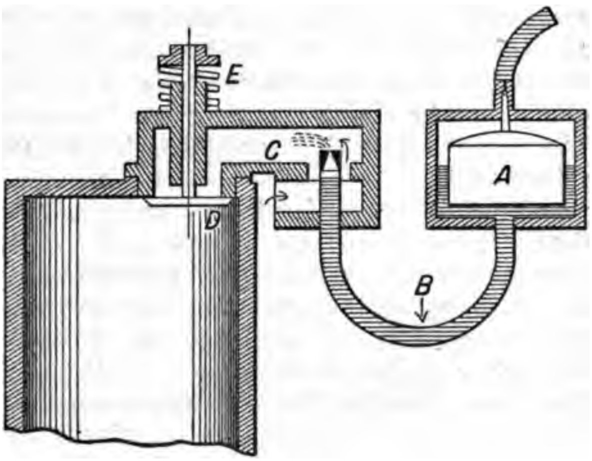


FIG. 10.—Section of Maybach carbureter.

reter are found to be: (1) It would vaporize the most volatile part of the gasoline and leave the residue, which is difficult to vaporize; (2) the slower the flow of air through the carbureter the more vapor it takes up, so that at small engine loads or slow speeds the mixtures were likely to be too rich if the adjustments were made for high speeds of the engine or rapid flow, and (3) the vaporization of the gasoline from the surface of the liquid cooled the liquid, because the latent heat of vaporization was largely absorbed from the liquid and the vaporization was slower as the liquid grew colder. In general this carbureter was incapable of maintaining a constant proportion of gasoline vapor to air at all rates of flow or at various temperatures of either air or gasoline and incapable of vaporizing all of the complex gasoline.

The first important improvement on this carbureter was made by Maybach, an engineer in the Daimler Works. This is shown diagrammatically in figure 10. Maybach's carbureter was designed primarily to make the apparatus independent of air temperature within a certain limit and independent of the rate of flow—that is to say, the speed and load of the engine—and likewise to prevent fractional distillation. The gasoline is delivered by gravity or pressure into the top of the chamber at the right through the opening, which is controlled by a needle valve attached to the float (A). As the float falls more liquid is admitted, which causes the float to rise, again decreasing the supply. The bottom of the float chamber is connected to the carbureter proper through the pipe (B). The air enters upon the aspirating stroke when the valve (D) is opened, whereby the pressure in the mixing chamber is made less than that of the atmosphere, so that the liquid fuel rises through the jet orifice by excess of pressure in the float chamber over the suction pipe and mixes with the air in the mixing chamber (C). It will be apparent that no valve is necessary except the one controlled by the float, and the fuel will only enter the mixing chamber (C) as required with the pressure variation on the suction stroke of the motor. The theory on which this type of carbureter was intended to maintain proportions was found in practice to be not quite true, although nearly enough so to make it a great advance. It was expected that by reason of the partial vacuum in the air pipe surrounding the gasoline jet, due to the engine suction, it would lift from the jet a quantity of the gasoline proportional to the quantity of air. In other words, assuming a vacuum in the suction pipe, the quantity of gasoline that would flow from the constant-level chamber, under the influence of the vacuum, would increase in the same proportions as the quantity of air flowing from the atmosphere to the same vacuum. It was found that as the vacuum increased, owing to the speed of the engine and the load, more fuel passed over than was wanted, assuming that the carbureter was properly set for small rates of flow. This led to the introduction of another valve opening to the atmosphere between the carbureter proper and the suction valve of the engine. To facilitate adjustment of the vacuum another valve is inserted into the air pipe, entering the carbureter, and to facilitate initial adjustment of the mixture a sharp-pointed valve called a "needle valve" was inserted over the gasoline jet or nozzle. The arrangement of such a carbureter as this is shown in figure 11. The maintaining of a constant level just beneath the gasoline nozzle was found to be rather difficult if the float stuck or the float valve leaked. For this reason diaphragms have been tried as a substitute, but their use is still experimental. The carbureter is otherwise the same essentially as described above.

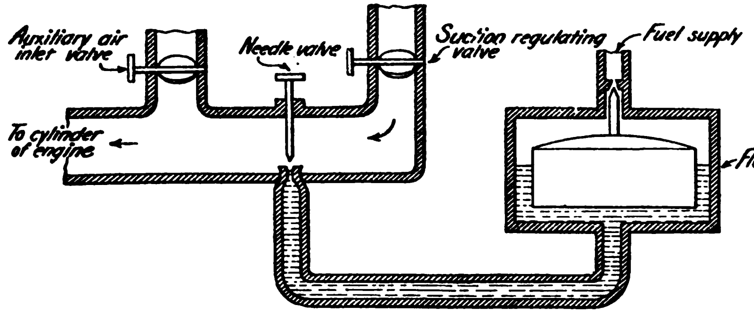


FIG. 11.—Diagrammatic section of constant-level carbureter, with needle-valve adjustment.

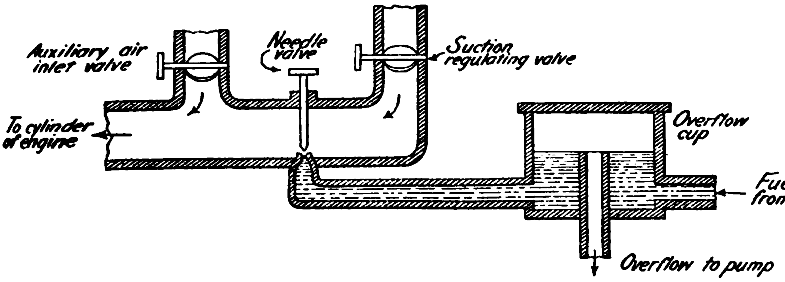


FIG. 12.—Diagrammatic section of constant-level carbureter, with overflow cup.

When the engine to be used is not in boats or automobiles, subject to shocks and oscillations, but is at rest, the third arrangement (fig. 12) can be employed to keep the fuel level constant in the nozzle and to prevent flooding of the carbureter. A small chamber is fed by a pump attached to the engine and working with it. Gasoline is supplied much in excess of what the engine will burn, and the excess is allowed to run back to the tank through an overflow pipe. This overflow pipe fixes the level of the gasoline in the spray nozzle.

This arrangement is selected as a desirable one because it is effectual and because the fire underwriters' rules require that the gasoline tank be placed below the level of the engine to minimize danger by fire. In some of the latest types of carbureters the valve between the carbureter proper and the suction, which is intended to open at high speeds, is made automatic and opens by a spring. This has given rise to the name "automatic carbureter." In order to more intimately mix the spray with the air, various devices have been introduced above the spray, such as cones, plain and corrugated, pieces of wire gauze at rest and spinning around under the influence of a fan driven by the entering air. In technical language these devices are known as "pulverizers," but really are nothing more than means for breaking up the gasoline into fine drops to permit of a more intimate mixture with air. It was supposed that the air would have sufficiently high temperature to absorb all the vapor that would be generated by the spray which was drawn into it, but in very cold weather or on very moist days it was found that at times the results were unsatisfactory. For this reason the air has been heated in some forms of carbureters by simply drawing it on its way to the carbureter through a chamber surrounding the exhaust pipe. When the gasoline carbureters are used for alcohol a higher temperature for vaporization and carburetion is required. Thus heating becomes a necessity, and, not only is it desirable to extract heat from the exhaust pipe by drawing air from the surrounding chamber, but in some cases the mixture also is passed through a heated chamber so that no particles of residue can remain unvaporized. In some forms of French carbureters the heat of the jacket water, which if it flows not too fast has a high enough temperature, has been used for the same purpose of heating the air, the liquid, or the mixture, to insure complete vaporization. But, as pointed out before, the alcohol will more or less vaporize at any temperature, and we have shown by our engine experiments that at ordinary temperatures, averaging about 60° to 80° F., enough alcohol can be vaporized to give a working mixture, although we also have evidence that all the alcohol does not vaporize, the remainder passing out as exhaust gases unburned or decomposed. The variation in important and unimportant details of construction in these carbureters intended either for kerosene, gasoline, or alcohol is almost beyond belief. Practically everybody who has ever had anything to do with these engines has designed a carbureter, and yet it can be proved beyond question that no carbureter on the market to-day, be it intended for any of the fuels named, is capable of carrying out that for which it was designed. While some vaporizers and carbureters to some extent will maintain the mixture perfectly well for some rate of flow or some particular temperature, no carbureter that has ever come to our attention will maintain an absolutely correct mixture for high speed and low speed, cold or hot air, moist or dry air, or changes in the rate of supply or engine load that must be met with in practical engine operation.

EFFECT OF INITIAL COMPRESSION.

By rather involved mathematical calculation it may be shown that the theoretical efficiency of an internal-combustion engine depends upon the amount of compression given to the combustible mixture during the compression stroke of the piston. The greater the compression the higher should be the efficiency. In practice it is found that various causes operate to diminish the efficiency, thus tending to offset the benefits of high compression. Still, with good mechanism it is found that an increase of compression up to a considerable amount improves the efficiency.

With gasoline the compression can not be carried much above 80 pounds per square inch without danger of premature explosion of the fuel charge in the cylinder. With alcohol the compression may be safely increased to 200 pounds per square inch if desired if the engine is well cooled, and in numerous European engines 150 pounds have been regularly used.

PRACTICAL EXPERIENCE WITH ALCOHOL ENGINES IN GERMANY.

There is one report available on the comparative value in unskilled hands doing commercial work of alcohol engines compared with the machines they have displaced, both with respect to fuel consumption and cost and the care and expense necessary for maintenance. Professor Strecker, of Leipzig, sent a circular letter to 120 farmers in Germany who were using alcohol engines, which had displaced steam engines for farm purposes. There were 120 of these engines, of three different makes and ranging in size from 6 to 25 horsepower.

These engines were working more or less throughout the year, the maximum number of hours being 2,500 per year, the minimum 324, and the average 996. The first question addressed to the farmers concerned the amount of work these engines were capable of doing compared with the engines they displaced at the same rated horsepower; 46 per cent thought them equal, 47 per cent thought them superior, and only 4 per cent considered them inferior, but qualified this by stating that the steam engine must be fired with greater regularity. The next question concerned the expense for fuel. The average amount of coal used in a steam engine was 4.28 kilograms per metric horsepower hour, equivalent to 9.55 pounds per brake horsepower hour, with an addition of 100 pounds per day for starting. The price of coal averaged 20.7 marks, which is equivalent to $4.47 per ton. The fuel used in the alcohol engine was not all the same. Nineteen per cent used German denatured alcohol, 81 per cent used a mixture containing 20 per cent benzole, and the consumption varied from 1.1 liters per German horsepower hour (2.35 pints per brake horsepower hour) maximum to 0.43 liter per German horsepower hour (0.92 pint per brake horsepower hour) minimum, the average being 0.57 liter per German horsepower hour (1.22 pints per brake horsepower hour).

Denatured alcohol cost at that time in Germany 17 marks per hectoliter (15.2 cents per gallon) and benzole costs 21.5 marks per hectoliter, equivalent to 19.4 cents per gallon. The 20 per cent benzole mixture therefore costs 17.9 marks per hectoliter (16.11 cents per gallon). Gasoline was almost invariably used for starting, and 85 liters (22.4 gallons) seems to be the average amount necessary per year, costing 36 marks per hectoliter (32.4 cents per gallon), with a total cost for starting of about 30 marks ($7.25) per year. The fuel consumption averaged 4.28 kilometers of coal per horsepower-hour (9.41 pounds) and 0.57 liter (1.2 pints per horsepower-hour) for alcohol. This is rather higher than reported in the various tests on these engines, but these figures represent the average of 74 engines, considering only those of 10 horsepower, and assuming that the large sizes balance the smaller sizes. With these figures a steam engine with an average of 10 horsepower operating 1,000 hours per year will cost $240 per year for fuel. The alcohol engine, operating the same number of hours at the price given, would cost $253 per year for fuel. This makes it appear that the cost of operation of the alcohol engine is greater than the steam engine in spite of superiority of the alcohol engine compared with steam. It is next pointed out that the transportation of alcohol in tanks and barrels is cheaper than that of coal (loose), and the convenience in handling and the elimination of a man constantly attending the fire, such as was found necessary with steam engines, really gives the alcohol engine a small advantage on operating cost. It was also shown that the cost of lubricants is no greater for the alcohol engine than for the steam engine, while the cost of repairs seems to be less. Of the 120 farmers, 9 per cent found the alcohol engine to cost more to maintain, 34 per cent found no difference, and 57 per cent found the maintenance less for the alcohol engine. Another interesting thing brought out by the inquiry was that the alcohol engine was capable of operating in all kinds of weather, in some cases with the temperature at 18° F. below freezing, only a little more time being required to start up. It was found also that there was absolutely no difficulty in instructing the ordinary person in the proper methods of handling and operating these engines.

The number of engines in use in Europe seems to be quite large, although definite information on this is difficult to obtain at the present time. One estimate, on fairly good authority, places the figure between 5,000 and 6,000 in Germany. The number that will probably be used in this country is difficult to estimate, but the large number of builders now engaged in turning out gas and gasoline engines—one firm alone being equipped to turn out 425 per day—seems to indicate that, if the cost of alcohol fuel compared with gasoline and coal be not too great a handicap, there is a probability of an exceedingly large industrial development in this field, though not immediately.

Besides the cost of alcohol per horsepower-hour compared with gasoline, there is another element that must be favorable before the introduction of the alcohol engine can become very wide, and that is the interest of the builders. From correspondence with the builders of gasoline and kerosene engines in this country, it appears that practically all of them are indifferent to the introduction of alcohol machines. They are quite willing that their regular engines be sold for and used with alcohol, but they are not inclined to give any guaranties on performance. Individually they are decidely averse in nearly every case to undertaking the development of a special alcohol engine, because this means extra expense in drawings, patterns, gigs, tools, etc., and it is certain that they will do very little so long as the public will continue to buy gasoline and kerosene engines and not insist upon having a specially designed alcohol machine.

CONCLUSIONS.

The following conclusions regarding the use of alcohol as fuel for engines as compared with gasoline are based on the preliminary results of the Department's experiments, upon results of the European experiments and investigations which have been presented in the foregoing pages, and upon the general knowledge of the authors:

(1) Any engine on the American market to-day, operating with gasoline or kerosene, can operate with alcohol fuel without any structural change whatever with proper manipulation.

(2) Alcohol contains approximately 0.6 of the heating value of gasoline, by weight, and in the Department's experiments a small engine required 1.8 times as much alcohol as gasoline per horsepower hour. This corresponds very closely with the relative heating value of the fuels, indicating practically the same thermal efficiency with the two when vaporization is complete.

(3) In some cases carbureters designed for gasoline do not vaporize all the alcohol supplied, and in such cases the excess of alcohol consumed is greater than indicated above.

(4) The absolute excess of alcohol consumed over gasoline or kerosene will be reduced by such changes as will increase the thermal efficiency of the engine.

(5) The thermal efficiency of these engines can be improved when they are to be operated by alcohol, first by altering the construction of the carbureter to accomplish complete vaporization, and second, by increasing the compression very materially.

(6) An engine designed for gasoline or kerosene can, without any material alterations to adapt it to alcohol, give slightly more power (about 10 per cent) than when operated with gasoline or kerosene, but this increase is at the expense of greater consumption of fuel. By alterations designed to adapt the engine to new fuel this excess of power may be increased to about 20 per cent.

(7) Because of the increased output without corresponding increase

in size, alcohol engines should sell for less per horsepower than gasoline or kerosene engines of the same class.

(8) The different designs of gasoline or kerosene engines are not equally well adapted to the burning of alcohol, though all may burn it with a fair degree of success.

(9) Storage of alcohol and its use in engines is much less dangerous than that of gasoline, as well as being decidedly more pleasant.

(10) The exhaust from an alcohol engine is less likely to be offensive than the exhaust from a gasoline or kerosene engine although there will be some odor, due to lubricating oil and imperfect combustion, if the engine is not skillfully operated.

(11) It requires no more skill to operate an alcohol engine than one intended for gasoline or kerosene.

(12) There is no reason to suppose that the cost of repairs and lubrication will be any greater for an alcohol engine than for one built for gasoline or kerosene.

(13) There seems to be no tendency for the interior of an alcohol engine to become sooty, as is the case with gasoline and kerosene.

(14) With proper manipulation, there seems to be no undue corrosion of the interior due to the use of alcohol.

(15) The fact that the exhaust from the alcohol engine is not as hot as that from gasoline and kerosene engines seems to indicate that there will be less danger from fire, less offense in a room traversed by the exhaust pipe, and less possibility of burning the lubricating oil. This latter point is also borne out by the fact that the exhaust shows less smokiness.

(16) In localities where there is a supply of cheap raw material for the manufacture of denatured alcohol, and which are at the same time remote from the source of supply of gasoline, alcohol may immediately compete with gasoline as a fuel for engines.

(17) If, as time goes on, kerosene and its distillates become scarcer and dearer by reason of exhaustion of natural deposits, the alcohol engine will become a stronger and stronger competitor, with a possibility that in time it may entirely supplant the kerosene and gasoline engines.

(18) By reason of its greater safety and its adaptability to the work, alcohol should immediately supplant gasoline for use in boats

(19) By reason of cleanliness in handling the fuel, increased safety in fuel storage, and less offensiveness in the exhaust, alcohol engines will, in part, displace gasoline engines for automobile work but only when cost of fuel for operation is a subordinate consideration. In this field it is impossible to conveniently increase the compression because of starting difficulties, so that the efficiency can not be improved as conveniently as in other types of engines.

(20) In most localities it is unlikely that alcohol power will be cheaper or as cheap as gasoline power for some time to come.

Issued April 3

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 278.

LEGUMINOUS CROPS FOR GREEN MANURIN

BY

C. V. PIPER,

Agrostologist in Charge of Forage Crop Investigations,
Bureau of Plant Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., January 16, 1907.

SIR: I have the honor to transmit and to recommend for publication as a Farmers' Bulletin the accompanying paper on "Leguminous Crops for Green Manuring," prepared by Prof. Charles V. Piper, Agrostologist in Charge of Forage Crop Investigations.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

Page.
Green manuring........ 5
The use of green manures........ 6
The principal leguminous crops........ 7
How legumes get nitrogen from the air........ 8
Inoculation........ 9
Sources of soil nitrogen........ 10
Loss of soil nitrogen........ 11
Composition of green-manure crops........ 11
Green manuring compared with feeding........ 12
Orchard cover crops........ 13
Crops to follow green manures........ 14
The choice of a green-manure crop........ 14
The principal green-manure crops........ 15
    Red clover........ 15
    Cowpeas........ 17
    Soy beans........ 19
    Velvet beans........ 21
    Crimson clover........ 22
    Sweet clover........ 24
    Canada peas........ 24
    Vetches........ 26
    Tangier peas........ 27

B. P. I.—247.

LEGUMINOUS CROPS FOR GREEN MANURING.

GREEN MANURING.

Green manuring, or the plowing under of green crops (figs. 1 and 2), is one of the oldest methods used to maintain or to increase the productivity of the soil. The effect of green manuring varies according to the original character of the soil. In general, sandy or gravelly soils are made darker in color and become more retentive of moisture. Clayey soils are made more porous and friable, so that they are less likely to puddle or bake, and are less subject to washing. Loamy soils are less noticeably affected than others.

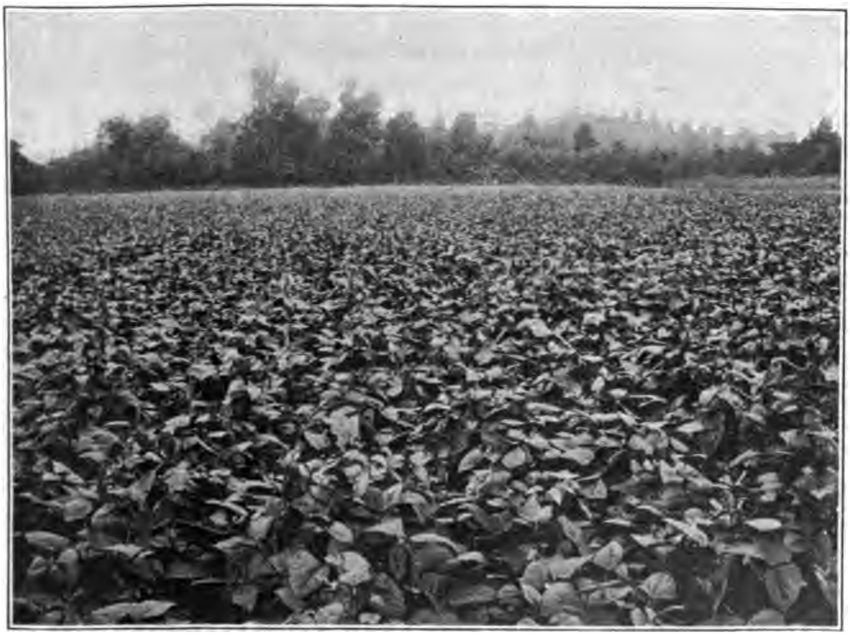


FIG. 1.—Field of cowpeas ready to plow under.

The most important object achieved by green manuring is the addition of humus to the soil. Other things being equal, the best green-manure crop is that which furnishes the largest amount of material which will readily decay in the soil and thus form humus. There are, however, additional ways in which such a crop may be beneficial. Deep-rooted plants are decidedly preferable to shallow-rooted ones because they penetrate into the subsoil. In this way air and water find entrance, especially after the roots decay. Thus in a way every deep-rooted plant is a subsoiler. It is also supposed that such plants, especially when plowed under, tend to enrich the surface soil with potash and phosphorus from the subsoil, thus bringing these substances within the reach of shallow-rooted plants.

Leguminous plants are more valuable for green manuring than others because they not only provide humus but also have the ability to use the nitrogen of the air, which upon decaying they add to the soil. For this reason green-manure crops should always be legumes if such are adapted to the particular locality where needed and can be sown at the time desired.

THE USE OF GREEN MANURES.

Green manuring as a definite farm practice can be recommended only under certain conditions. It is profitable in upbuilding poor soils and in improving the physical condition of sandy, clayey, and adobe soils. In orchards green manures may, as a rule, be used very advantageously, as they do not interfere with the fruit crops.

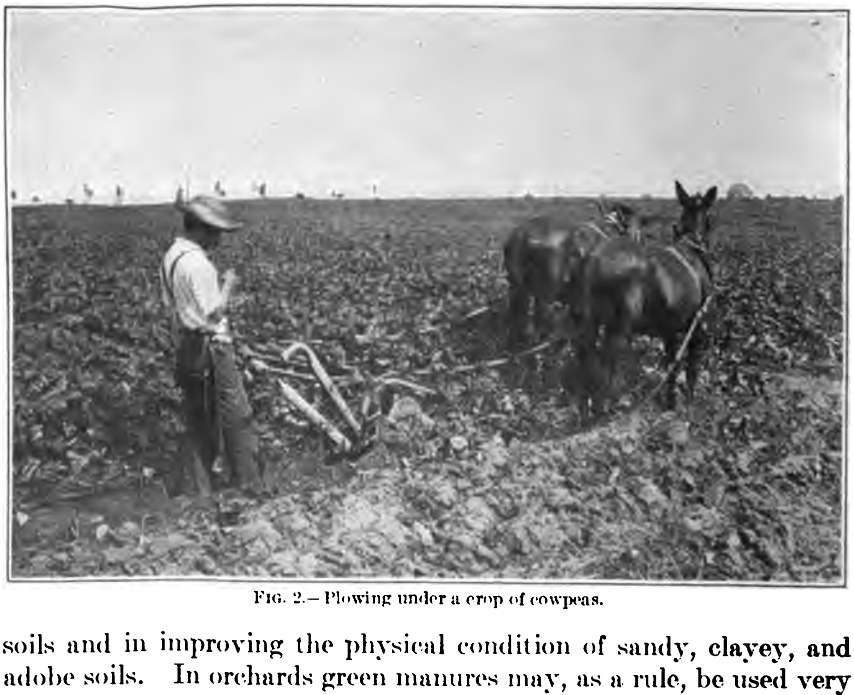


FIG. 2.—Plowing under a crop of cowpeas.

Green manuring can not be recommended on good soils, except at long intervals when there is reason to believe that there is need either of more humus or more nitrogen. Where red clover or alfalfa can be used in rotation the need of a special green-manure crop is seldom felt.

The reason lies in the fact that about one-third of the weight of the clover plant and nearly one-half of that of alfalfa is in the root, so that these plants virtually produce a green-manure crop under the ground in addition to the regular crop of hay. Sweet clover is another plant of this class and of wide adaptation as to soil and climate, but unfortunately the hay is not readily eaten by cattle, so that it is used in limited sections only.

A serious objection to a green-manure crop lies in the fact that it must ordinarily take the place of a regular crop, so that the income from the land is lost for the season. The value of the practice in any particular case must be measured by the results secured in the subsequent crop. Frequently it will happen that as good or nearly as good results can be obtained by the use of commercial fertilizers; in such cases it is often best to use them, thus retaining the use of the land for the season. Sooner or later, however, the humus of the soil becomes depleted and must be replaced. Where clover or some similar large-rooted crop can not be used in rotation, recourse must be had either to green manuring or to the application of barnyard manure.

The use of green manures in semiarid regions is as a rule impracticable, as with insufficient moisture vegetable matter decays very slowly. The soil is thus filled with air spaces and loses much more water by evaporation.

THE PRINCIPAL LEGUMINOUS CROPS.

There are in the United States 15 leguminous field crops that are more or less extensively grown. In the approximate order of their importance they are as follows: Red clover, alfalfa, cowpeas, alsike clover, crimson clover, white clover, Canada peas, soy beans, peanuts, vetch, velvet beans, Japan clover, and bur clover. A few more are cultivated to a less extent, as sweet clover, beggarweed, grass peas, fenugreek, and horse beans. Many others have been tested in an experimental way, but as yet are not grown as crops.

From an agricultural point of view legumes may be classified into three groups: (1) *Summer annuals*, including cowpeas, soy beans, peanuts, beans, velvet beans, and in the North common vetch and Canada peas; (2) *Winter annuals*, comprising crimson clover, bur clover, hairy vetch, and in the South common vetch and Canada peas; (3) *Biennials or perennials*, embracing red clover, white clover, alsike clover, alfalfa, and sweet clover.

Each of these crops can be grown advantageously only in a more or less definitely limited region. For the particular purpose in view, it rarely happens that a choice of two or more equally valuable legumes is offered. Usually one is so much superior to any other available that substitution is practically out of the question. In a few cases, however, the use of one legume in place of another is practicable. Thus cowpeas and soy beans are agriculturally much alike and are adapted to nearly the same regions. In a like manner crimson clover, bur clover, and the vetches over a large area may be used one in place of another. In some sections the culture of red clover is no longer profitable, principally owing to diseases. Alsike clover has been used to some extent as a substitute, but the yield is ordinarily much less. There is also an increasing use of alfalfa in place of red clover, but with alfalfa the best practice is to keep the fields in this crop three years or longer.

HOW LEGUMES GET NITROGEN FROM THE AIR.

It was known even in ancient times that much larger crops of various kinds could be produced on land that had been in clover or lupines the previous season.

In modern agriculture the value of legumes is quite generally appreciated, as seen in the common practice of growing clover or some other legume in rotation at frequent intervals. The reason why legumes have a beneficial effect was discovered by Hellriegel and Wilfarth in 1886, though many accurate experiments had long before proved the fact.

An examination of the roots of leguminous plants will reveal on many of them nodules or tubercles; sometimes very few, sometimes very many. (See figs. 4, 7, and 14.) These vary in size and shape according to the kind of plant. Thus, on red clover (see fig. 4) they are more or less round, and quite small; on the cowpea they are also round and nearly smooth, but much larger; on the velvet bean they may even reach the size of a pigeon egg; on the vetches they are irregular, both in shape and size. The differences in the tubercles are such that in many cases it is possible to determine the plant to which the root belongs.

Hellriegel and others have proved beyond any question that when leguminous plants have these tubercles on the roots they can make use of the free nitrogen of the air; when they do not have these tubercles they are powerless to do this, but must obtain their supply of nitrogen from the soil in the same manner as most other plants. It has further been proved that these tubercles are caused by a certain kind of bacteria, and that it is really by these bacteria that the nitrogen of the air is absorbed so that it can be used by the clover or by other legumes. There is thus a peculiar interrelation established between the leguminous plant and the bacteria. The latter obtain their principal nourishment from the legume, while in turn they provide nitrogen from the air which can be used by the host plant.

INOCULATION.

Nearly every legume has its own particular strain of nodule bacteria. For example, that of the clover is different from that of alfalfa, and that of the cowpea distinct from that of the soy bean. In planting a leguminous crop for the first time it will therefore often happen that no tubercles will form on the roots, because the proper kind of bacteria is not present in the soil. These may be supplied by scattering soil from a field where the crop in question has been recently grown, or by using an artificial culture of the proper bacteria. After the field is once thoroughly inoculated there is rarely any difficulty afterwards in getting an abundant supply of root tubercles.

The same strain of bacteria will often inoculate different closely related legumes. Thus alfalfa, bur clover, and sweet clover are tubercled by the same strain; a different strain inoculates most kinds of vetches, as well as the field and garden peas; still another strain is apparently used by red clover, white clover, and alsike clover in common.

There is a marked variation among different legumes, both in the extent to which they are naturally tubercled and in the ease with which different ones may be artificially inoculated. Natural inoculation presupposes the existence of the proper germ in the soil, and this is nearly always present over areas where a particular legume has been generally grown. Thus red clover is practically always naturally inoculated in the northeastern quarter of the United States and cowpeas in the southeastern. Alfalfa is naturally tubercled as a rule in the West, while in the East artificial inoculation is usually necessary.

Artificial inoculation is usually accomplished with ease as regards cowpeas, red clover, vetches, field peas, and most other legumes. Soy beans, however, frequently give negative results. Sweet clover is much more readily inoculated than alfalfa, though both use the same strain of bacteria.

In some cases the tubercle germs occur in sufficient abundance on the seeds to provide inoculation. This occurs more particularly on seeds that are tramped out by oxen or which otherwise become covered with dust from the field. An interesting illustration of this occurred in 1906 in the case of guar, an East Indian legume. Neither this plant nor any closely related species had previously been grown in this country. Nevertheless, at Chillicothe, Tex., the plants were abundantly tubercled.

SOURCES OF SOIL NITROGEN.

Nitrogen, as purchased in commercial fertilizers, such as nitrate of soda, guano, tankage, and dried blood, is the most expensive manurial substance a farmer has to buy. Its cost in these various forms ranges from 15 to 20 cents a pound. To a very large extent, at least, the purchase of the costly nitrogenous fertilizers can be avoided by the growing of green-manure crops, especially legumes.

There are two principal ways in which nitrogen is naturally added to the soil. The first and much more important way is by means of legumes. This takes place only when the roots of the leguminous plant bear bacterial nodules or tubercles. The amount of nitrogen that any particular legume can add is directly proportional to the number and size of the tubercles on its roots. Little is known regarding the relative abilities of different legumes to fix atmospheric nitrogen, though they differ widely. It has sometimes been assumed that those are most efficient whose herbage is richest in this substance. This is at least questionable, as these same species may be able to utilize more of the soil nitrogen than others.

The second way in which nitrogen is added to the soil is through the activity of certain soil bacteria. These, especially if provided with decaying vegetable or animal matter, are able to use the nitrogen of the air, forming nitrogen compounds. The amount of the nitrogen thus fixed depends on a number of factors. A supply of decaying material must be available as food for the bacteria, the soil must be well aerated and must not be sour, and there must be lime or other substance in the soil with which the nitrogen can be combined. With these conditions fulfilled the bacteria are most active when the soil is warm--that is, in summer. It is now believed that the principal benefit achieved by summer fallowing is the increase in the amount of nitrogen by soil bacteria. It may here be pointed out that in experiments green-manure crops have yielded the best results when turned under shallow. This result is perhaps due to the fact that the best conditions are thus provided for the activity ot the soil bacteria.

Two general methods of determining the amount of nitrogen added to the soil by a leguminous crop have been employed. The first is by analyzing the soil before the crop is grown and again afterward. The other method is to determine the nitrogen content of plants with tubercles as compared with those that have no tubercles. The difference will show approximately the amount of nitrogen gathered from the air. The error, if any, in the latter method will be an underestimate, as there is reason to believe that some nitrogen passes from the root tubercles to the soil before the plant is mature.

At the Illinois Agricultural Experiment Station it was found that cowpea plants with tubercles on the roots were not only much larger, but that they also were much richer in nitrogen. Those with tubercles yielded 3.96 per cent of nitrogen, while those without tubercles had but 2.22 per cent of nitrogen.

At the Michigan Agricultural Experiment Station it was found that soy beans with tubercles on the roots yielded 113.55 pounds of nitrogen per acre, while those without tubercles yielded but 75.98 pounds. Cowpeas yielded, respectively, 139.21 and 118.45 pounds. Thus the soy bean tubercles increased the amount of nitrogen by 37.57 pounds per acre, or nearly 50 per cent, while the cowpea increase was but 20.76 pounds per acre, or a little more than 20 per cent.

LOSS OF SOIL NITROGEN.

It is important to know that under certain conditions nitrogen may escape from the soil as a gas. This result is brought about principally by certain organisms, called denitrifying bacteria, that break up nitrogen compounds and permit the nitrogen to escape, usually in the form of ammonia. Little is yet known of this process, but it is believed to occur under various different conditions. There are probably different bacteria which under different conditions cause these losses. It is known, however, that large loss is likely to occur when there is present abundant decaying matter, high temperature, and lack of air. Such losses occur particularly in rich water-logged lands and in manure heaps. For these reasons it is not good practice to endeavor to obtain a large store of nitrogen in the soil beyond the needs of the crops. For the same reason green-manure crops should not be used on lands that are decidedly wet.

COMPOSITION OF GREEN-MANURE CROPS.

The essential fertilizing substances added to the soil as manures are nitrogen, phosphorus, and potash. The accompanying table gives the amount of these substances in both the tops and roots of several legumes, as shown by a number of analyses of each.

It has been found that all plants vary widely in the relative amount of these materials they contain. The same plant varies when grown on different soils or in different seasons on the same soil. The cause for the variation in nitrogen has been fully explained. The reason for the variation as regards the other substances which are obtained wholly from the soil are obscure. In the accompanying table it will be noted that the variation in legumes as regards phosphorus and potash is nearly as great in any one legume as it is between different legumes. It has been suggested by several writers that certain green-manure crops by feeding heavily on phosphorus and potash make these substances more available to subsequent crops. It is very doubtful whether this is true, but if it is there is little apparent advantage of any one legume over another in this respect.

Fertilizing materials in 100 pounds of dry substance.

[Compiled from various sources.]

Plant and part.	Nitrogen.	Phosphoric acid.	Potash.	Plant and part.	Nitrogen.	Phosphoric acid.	Potash.
Red clover:	*Pounds.*	*Pounds.*	*Pounds.*	Cowpea—Cont'd.	*Pounds.*	*Pounds.*	*Pounds.*
Tops	2.56	0.72	1.40	Tops	2.09	.56	3.04
Tops	2.07	38	2.20	Roots	1.19	.67	1.94
Tops	1.97	.56	1.86	Roots	.68	.64	1.16
Tops	2.81	.65	3.10	Roots	1.46	.16	.77
Roots	2.74	.84	.82	Roots	1.40	.73	.76
Alfalfa:				Soy bean:			
Tops	2.42	.58	1.42	Tops	2.06	.80	1.20
Tops	2.30	.53	1.46	Tops	2.32	.67	1.08
Tops	2.19	.51	1.68	Tops	2.97	.55	1.98
Roots	2.04	.43	.48	Tops	2.60	.65	2.23
Crimson clover:				Tops	1.53	.57	1.76
Tops	2.38	1.10	1.56	Tops	2.01	.65	2.17
Tops	2.05	.40	1.31	Tops	1.75	.40	1.32
Tops	1.95	.36	1.17	Roots	.81	.36	.90
Roots	1.50	.47	1.02	Roots	1.22	.32	.24
Cowpea:				Roots	1.11	.35	.87
Tops	2.32	.51	2.92	Velvet bean	2.51	.53	3.84
Tops	1.81	.65	1.29	Common vetch:			
Tops	1.59	.30	1.53	Tops	3.53	.74	2.56
Tops	1.95	.52	1.47	Tops	3.18	.77	3.50
Tops	1.75	.45	1.27	Tops	2.27	.62	1.97
Tops	2.23	.57	2.00	Roots	2.19	.79	1.18

GREEN MANURING COMPARED WITH FEEDING.

Barnyard manure contains from 75 to 90 per cent of the total fertilizing substance in the feeds used. It is beyond question a better practice from all standpoints to feed a crop, whether leguminous or nonleguminous, and then distribute the manure over the land, than it is to plow under the whole crop. This practice utilizes the whole feed value of the crop. Further, it returns an important part of it to the soil in a highly available form for plant food. Unquestionably this is the very best farm practice in maintaining soil fertility. Were it possible on any farm to feed the entire product to live stock, returning the manure to the soil, the productivity of that farm would be maintained indefinitely. The only depletion that would occur would be the comparatively small amount of potash and phosphorus sold in the live-stock product. The loss of nitrogen would be more than maintained by the activity of the soil bacteria.

It is, of course, well known that other causes than the removal of plant food may reduce the productivity of the soil. Such causes as sour soil, the deleterious effect of one crop upon the succeeding one, and poor tillage may and often do result in poor crops. These causes are, however, largely within the control of the farmer and in no way affect the general statements above made.

The feeding of crops, taken as a whole, is necessarily limited by the total demand for live stock. The total number of live stock required to supply the market demands can furnish but a small proportion of the manure needed. On this account the practical use of barn manure is naturally limited to regions where animal husband prominent. Where stock raising is but little developed rec must be had to other fertilizers. It is primarily in such regions the use of green manures is necessitated.

ORCHARD COVER CROPS.

The term "cover crops" was originally used to include grown for various diverse purposes, such as to prevent soil washin hold drifting snow, for keeping the soil warm in winter, and to h the ripening of wood. As these crops were used largely in orch and as they were often legumes, so that they might serve also as manures, the term "cover crop" is frequently used to include grown in orchards primarily for green manure.

The growing of leguminous crops in orchards is generally sidered excellent practice, except in dry regions where irrigati impracticable.

In the citrus orchards of southern California a number of diff legumes are used as winter cover crops; among them Canada common vetch, hairy vetch, and fenugreek. Besides these, others have been tried in an experimental way, such as horse b scarlet vetch, black-purple vetch, lupines, sweet clover, and bers The two first mentioned are most used at present, and the ge opinion is that the practice is decidedly profitable. There is, ever, a lack of accurate data on this point. Some orange gro are also using cowpeas as a summer cover crop.

In Delaware and other States of the Atlantic seaboard, cri clover is the most common legume used as a cover crop. To a extent common vetch and hairy vetch are employed.

At the Ohio Agricultural Experiment Station it was found apple trees grew more rapidly and yielded larger crops when orchard was kept in grass. After each mowing the straw was use a mulch about the trees. Where the trees were cultivated in a of 3 or 4 feet about the base, the results were distinctly inf Clean summer culture with a winter cover crop gave results i mediate between the other two.

It is probable that the best results in different portions of country will be obtained by different methods. There is much of determining accurately the results of different treatment shown both by the growth of the trees and the crop produced.

CROPS TO FOLLOW GREEN MANURES.

The plowing under of large quantities of green herbage, as illustrated in figure 2, p. 6, especially when this is done during the summer, often brings about the formation of considerable acid, or, in other words, makes the soil sour. This condition may be corrected by the use of lime, which should be applied at the rate of a ton to a ton and a half to the acre. Some farmers claim to get much better results by applying the lime before plowing under the crop. In any case, it is advisable to let the green manure after being plowed under decay a month or more before planting the succeeding crop.

The full results of a green manure are obtained only after it is completely decayed and changed into a soluble form. This requires considerable time, so that the beneficial results are often shown for two or more seasons.

Generally speaking, cultivated crops are the best to follow green manures. The tillage of such crops hastens the decay of the vegetable matter and, by aerating the soil, favors additional nitrogen fixation by the soil bacteria. Corn, cotton, potatoes, and tobacco, on most soils, derive great benefit when following green manures. Rye and oats are likewise good crops to use in this way. Wheat and barley give varying results, often very favorable, but not infrequently there is no increase or even a loss. This is especially true the first season following a green-manure crop.

THE CHOICE OF A GREEN-MANURE CROP.

Whenever a green-manure crop is to be used, preference should be given to a legume if it is available, because such a crop will add materially to the nitrogen content of the soil. Where there is a choice between two or more legumes, the question arises as to which is to be preferred. Among the important points that determine the value of a leguminous crop are (1) its value as forage, both in quantity and quality, either as hay or pasture; (2) its ability to supply additional nitrogen. Other points that deserve consideration are the cost of the seed, the ease of plowing under the crop, the deep-rootedness of the plants, and their ability to choke out weeds. On lands of fair quality the largest profit is usually obtained by using the crop as fodder. This may be done by harvesting it for hay, leaving only the stubble to be added to the soil, or by pasturing the crop, by which means the most of it is returned to enrich the land.

Where the whole crop is plowed under, the effect on the subsequent crops is determined mainly by three factors, namely, the amount of humus formed, which is directly measured by the tonnage of the crop; the physical changes brought about in the soil, and the quantity of nitrogen taken from the air and added to the soil. It is generally believed that the addition of nitrogen is the most important of these factors. While different legumes are known to vary in their respective abilities to absorb atmospheric nitrogen, there is much yet to be learned on the subject. If the benefit of different legumes is proportional to the amount of nitrogen each adds to the soil, then their relative values can be determined in advance. Thus far the value of different green manures has been determined wholly or mainly by the influence they have on the succeeding crop or crops.

THE PRINCIPAL GREEN-MANURE CROPS.

RED CLOVER.

Red clover (figs. 3 and 4) is the most common legume used in rotations in the Northern States. It is usually grown with timothy, following wheat or other small grains. As a general rule the timothy seed is sown in the fall with the grain, and the clover is sown the following spring. While the beneficial effect of plowing under red clover or red clover sod is well known, there has been but little work done at the agricultural experiment stations to determine accurately the amount of benefit thus secured. Results obtained at the Illinois Agricultural Experiment Station gave an average yield of $35\frac{7}{10}$ bushels of corn where this crop was grown year after year on the same land. In rotations, the average yield was $55\frac{1}{10}$ bushels for the first crop after clover and $48\frac{3}{5}$ bushels for the second crop after clover.

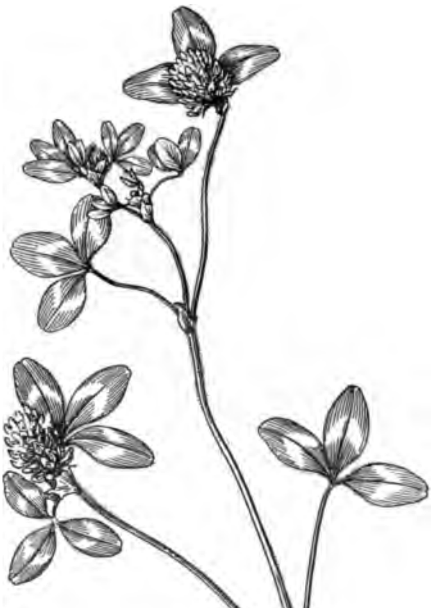


FIG. 3.—Red clover.

Some exceedingly interesting results on red clover as a green manure, secured by the Central Experimental Farm, Ottawa, Canada, have recently been published. In one of these experiments four plats were planted to spring grains with red clover and four to the same grains without red clover. After the grain crops were harvested the clover was allowed to grow on the four plats, and having attained a good growth was plowed under in October. The remaining four plats without red clover were plowed at the same time. The following spring all eight plats were seeded to oats. Those that had been in clover yielded an average of $49\frac{9}{10}$ bushels to the acre, against $38\frac{4}{5}$ bushels for the plats that had no clover. All four of the plats that had been in clover showed an increase, the greatest being $19\frac{2}{5}$ bushels and the least $7\frac{1}{5}$ bushels. Without additional fertilizers the same plats were seeded the following year to barley. Those that had been in clover yielded an average of $37\frac{3}{5}$ bushels to the acre, while the others yielded but 29 bushels. This experiment furnishes a clear demonstration that the good effect of the clover lasts more than one season.

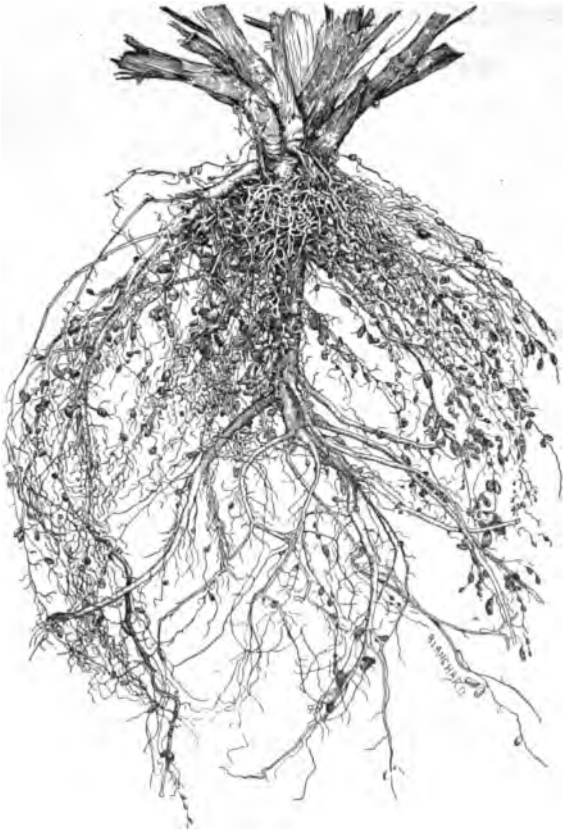


FIG. 4.—Roots of red clover showing nodules.

In another experiment oats were grown on four plats, following, respectively, brome-grass, mixed grass without clover, mixed grass with clover, and clover alone. The respective yields were $33\frac{1}{10}$, $36\frac{3}{10}$, $46\frac{1}{10}$, and $43\frac{1}{2}$ bushels. The average of the two plats where no clover had been used was $34\frac{1}{2}$ bushels, while that of the two where clover had been used averaged $44\frac{1}{2}$ bushels. The benefit derived from the red clover therefore amounted to 10 bushels per acre more than was derived from the grasses.

Other experiments conducted in this same series showed very marked favorable results both to crops of fodder corn and potatoes following clover. In the case of corn the increase amounted to 40 per cent and in the case of potatoes to 28 per cent.

COWPEAS.

The cowpea (fig. 5) is used more than any other crop as a soil renovator in the South. Its use is rapidly increasing, but is yet far from general. During the past few years the high price of the seed has tended to discourage more extensive growing. Recent progress in the harvesting of cowpea seed by machinery will doubtless materially reduce its cost. The seed is at present almost entirely picked by hand.

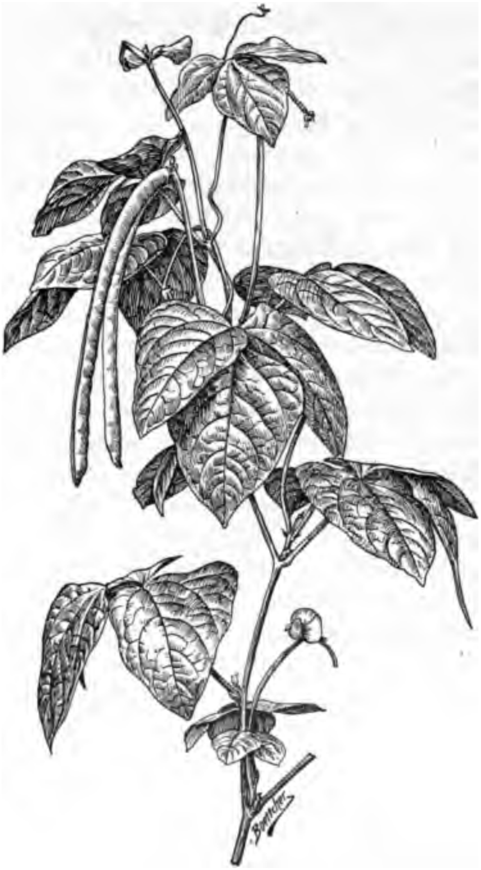


FIG. 5.—Cowpea.

The cowpea is characterized by remarkable ability to grow in poor soils and to cover the ground so densely as to choke out most weeds. It usually bears an abundance of tubercles on its roots, whether the soil has been inoculated or not, although in new localities where the cowpea has not been previously grown the tubercles may be absent. In such cases inoculation is necessary, for it must always be remembered that it is through the tubercles on the roots that the beneficial effects of the cowpea or other legume largely depend.

Cowpeas are very commonly planted between rows of corn at the time of the last cultivation, or they are broadcasted upon the stubble of small grains. Cowpeas, however, like other crops, respond markedly to cultivation and there is a growing tendency to plant them upon well prepared soil. This practice results in a great increase of the crop, whether grown for hay or for seed. (See fig. 1, p. 5.)

More numerous experiments have been conducted in this country to determine the effects of cowpeas used as a green manure than have been devoted to all other leguminous crops combined. Almost without exception these experiments have indicated a very beneficial effect upon the succeeding crop. The benefit often lasts two or three years. These good results follow on practically all succeeding crops, whether cotton, corn, sorghum, or small grains. Except on the poorest soils careful experiments show that it is decidedly more profitable to use the cowpea crop as hay or pasture and then plow under the stubble than it is to plow under the whole crop. While plowing under the whole crop produces as a rule a greater effect, it is not enough greater to equal the value of the cowpea crop as feed.

A few of the striking results obtained at southern experiment stations are here given. At the Arkansas Agricultural Experiment Station the effect of cowpeas upon the succeeding wheat crops was studied for a period of four years. The land on which the experiments were conducted had all been in wheat in 1898. This was divided into equal plats, and on some of these plats Whippoorwill cowpeas were planted, while others were left bare. The average yield on two plats where wheat was grown continuously and no cowpeas were used was $10\frac{1}{10}$ bushels. On two other plats where a crop of cowpeas was plowed under in the autumn of 1898 the average yield was increased to $14\frac{1}{10}$ bushels for the four years, and the beneficial effect of the cowpeas plowed under in 1898 persisted, with a gradual diminution, through the four succeeding years. Where only cowpea stubble was plowed under in the autumn of 1898 the average yield for the four years was $12\frac{3}{5}$ bushels, and a slight beneficial effect was still observable in the fourth year. On two other plats cowpeas were planted each season after the wheat was harvested and the stubble plowed under. The average yield of wheat on these plats was $14\frac{2}{5}$ bushels. Furthermore, the yield on these last two plats increased year after year until the last year of the experiment, one of them yielding $16\frac{9}{10}$ bushels and the other $17\frac{3}{5}$ bushels, the highest yields reported in the entire experiment. In comparison with these experiments with cowpeas other plats were also treated with commercial fertilizers. The effect of adding 200 pounds of nitrate of soda in the autumn of 1898 raised the average yield of wheat to nearly 11 bushels per acre and the entire additional effect was obtained during the season following the application. Where 800 pounds of complete fertilizer were used in the autumn of 1898 the average yield of wheat was increased to 13 bushels per acre, the most marked effects being during the first and second years. On the soil where these experiments were conducted there is thus a clear advantage in favor of the cowpeas, even if the value of the cowpea crop in itself be ignored.

Among the numerous experiments with cowpeas conducted by the Alabama Agricultural Experiment Station were a number to determine the effect of plowing under cowpea vines on a succeeding crop of cotton. The yield of seed cotton thus produced in 1899 was 1,533 pounds, as against 837 pounds on an adjoining plat that had been in cotton the previous season, thus giving a clear gain of 696 pounds of seed cotton, valued at $17.40.

In another experiment sorghum yielded 5.66 tons of hay following cowpea stubble, 5.72 tons following cowpea vines plowed under, and only 3.65 tons following a previous crop of sorghum. The cowpeas here in each case gave a clear increase of more than two tons per acre.

In a third experiment oats following cowpea vines plowed under yielded $22\frac{4}{5}$ bushels per acre, while following German millet plowed under they yielded only $12\frac{2}{5}$ bushels. In another similar experiment oats following cowpea stubble yielded $34\frac{2}{5}$ bushels and following cowpea vines plowed under $28\frac{4}{5}$ bushels, while following German millet the yield was $9\frac{9}{10}$ bushels. These last experiments indicate that the effect of a leguminous green-manure crop is probably due largely to the nitrogen which it adds to the soil, as it may be assumed that the amount of humus supplied by the millet was approximately equal to that added by the cowpeas. It is possible, however, that the millet may have tended to reduce the normal yield instead of increasing it.

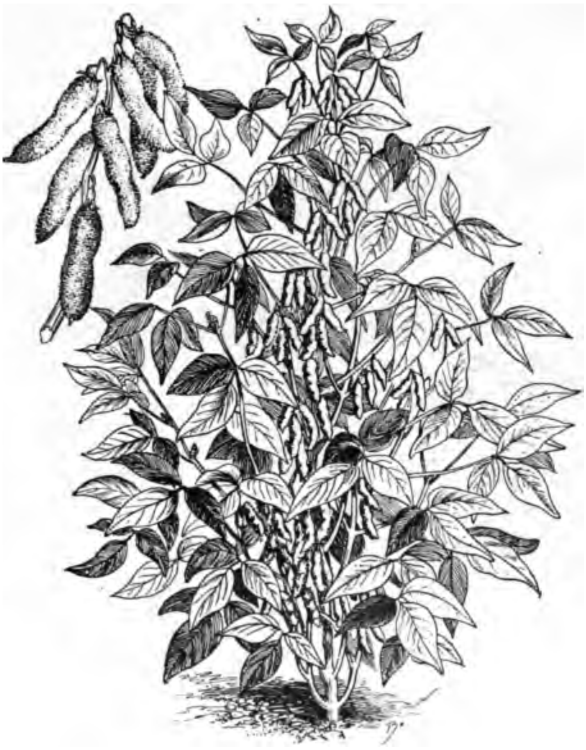


FIG. 6.—Soy bean.

SOY BEANS.

Soy beans (fig. 6) are adapted to a much wider range of climate than cowpeas, being grown successfully even in Ontario and Massachusetts. As a forage crop soy beans have some points of superiority over cowpeas, the hay being somewhat easier to cure and richer in protein. The seed is also cheaper than that of cowpeas, usually costing only two-thirds as much. This is principally due to the fact that the seed can readily be harvested by machinery. It also has an advantage in that the seeds are but little affected by weevils. On these accounts soy beans are preferred by an increasing number of farmers in the South. Soy beans, however, are not able to compete with weeds as successfully as cowpeas, and on this account the best results are obtained by planting in rows, so that they may be cultivated. There is considerable difficulty experienced at first in obtaining tubercles on the roots of soy beans, but when once these have appeared in a particular piece of ground there is no further trouble. Apparently, soy beans have a greater power than cowpeas to absorb atmospheric nitrogen through their roots (fig. 7).

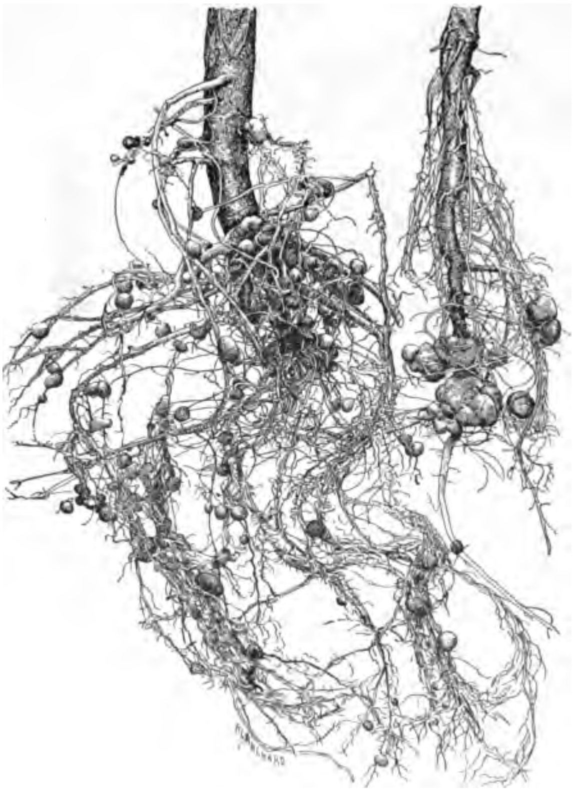


FIG. 7.—Roots of soy bean, showing nodules.

In an investigation conducted at the Michigan Agricultural Experiment Station it was found that inoculated soy beans were enabled to add per acre 37.57 pounds of nitrogen provided from the air. (See p. 11.) At the Arkansas Agricultural Experiment Station soy beans used as green manure gave nearly as good results as cowpeas, as determined by subsequent crops of wheat, oats, cotton, and corn. With cotton, the soy bean vines produced a larger yield of cotton than cowpea vines, but the cowpea stubble gave a larger yield than the soy bean stubble. With corn, cowpea stubble and soy bean stubble yielded the same results, while soy bean vines gave better results than the cowpea vines. With oats, the results were slightly in favor of the cowpeas. It is not improbable that the variation in results may be largely due to variation in the amounts of atmospheric nitrogen added by the legumes to the different plats. Those that were most heavily tubercled would add the most nitrogen.

VELVET BEANS.

Velvet beans (fig. 8) have been tested in comparison with cowpeas at the Arkansas and Alabama agricultural experiment stations. The velvet bean is somewhat objectionable on account of the very viny habit of the plant, which renders it difficult to plow under. In orchards velvet beans have been found objectionable on account of their tendency to climb the trees. At the Arkansas Agricultural Experiment Station velvet beans gave better results on a subsequent crop of cotton than either soy beans or cowpeas, the velvet bean plat yielding 1,550 pounds of seed cotton, against 1,448 pounds for the soy beans and 1,335 pounds for the cowpeas. With wheat, velvet bean stubble gave better results than either cowpea stubble or soy bean stubble, though the difference was very slight. It is noteworthy also that velvet bean stubble gave much better results on the succeeding crop of wheat than where the whole crop of velvet bean vines was plowed under, and the same was true in regard to both cowpeas

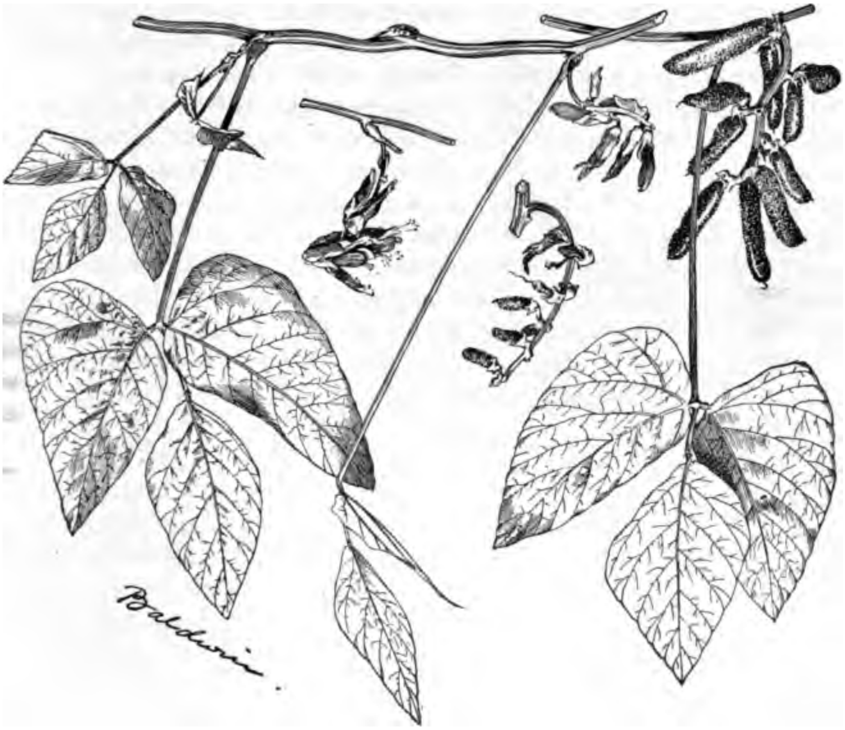


FIG. 8.—Velvet bean, showing leaves, flowers, and young pods.

and soy beans. In all cases, however, there was a marked increase of crop, due to the influence of the legumes.

At the Alabama Agricultural Experiment Station the following yields of sorghum hay were obtained: After fallow, 3,792 pounds per acre; after cowpeas plowed under, 7,008 pounds; after velvet beans plowed under, 7,064 pounds. Here the legumes nearly doubled the yield of the sorghum hay, the velvet beans being slightly better than the cowpeas. In a similar experiment where only the stubble was plowed under, the velvet beans in two cases showed a slight superiority over the cowpeas. Where corn was used to determine the effect of the legume, cowpeas gave slightly better results than similar plats with velvet beans, whether the stubble or the whole vines were plowed under. Where cotton was used as a measuring crop, the results were in favor of the cowpeas. The cowpea plat produced 1,533 pounds, the velvet bean plat 1,373 pounds, and the check plat 837 pounds, respectively, of seed cotton. Comparison of all the results obtained showed that there is practically no difference as regards fertilizing value between velvet beans and cowpeas.

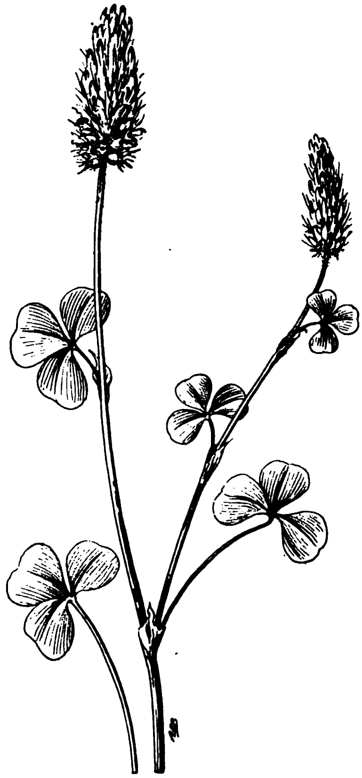


FIG. 9.—Crimson clover.

CRIMSON CLOVER.

Crimson clover (fig. 9) is much grown as a green manure and forage crop along the Atlantic seaboard from New Jersey southward and to a less extent in the Gulf States. It has been grown to a slight extent in various other States, but owing to the frequency with which it winterkills it has not been established as an important crop. It is most largely grown in the Middle Atlantic States, and its use has greatly increased in late years.

Crimson clover gives the best results when sown in late summer, preferably from July 15 to September 1. It is most commonly planted in corn or following a small grain crop. In the latter case the land should be plowed and put in good condition before seeding. Considerable difficulty is often experienced in obtaining a stand of crimson clover. Indeed, it is a common saying that it must be sown between showers in order to be assured of a stand. It is important always to use fresh seed, as the germinating power deteriorates rapidly. Ordinarily 12 to 15 pounds per acre is used, but good results have been obtained with smaller quantities. In some cases the failure to obtain a stand has been attributed to the lack of inoculation. In any event it is always desirable to inoculate the seed or the soil before planting on land for the first time. Even if a stand is only obtained two times out of three crimson clover is still a very profitable crop to grow.

A number of careful experiments with crimson clover have been conducted both by the Delaware and Maryland agricultural experiment stations. At the Maryland Agricultural Experiment Station it was found that potatoes following crimson clover plowed under yielded $72\frac{3}{10}$ bushels per acre, while on an adjoining plat where no crimson clover had been sown the yield was $52\frac{4}{5}$ bushels. On the same plats the following year the yields were, respectively, $102\frac{1}{5}$ bushels and $67\frac{4}{5}$ bushels—an increase of 27 bushels per acre, or more than 45 per cent, due to the effect of the crimson clover. In a similar experiment with corn a yield of 46 bushels per acre was obtained following crimson clover, as against $39\frac{3}{10}$ bushels where no clover had been sown. At the Delaware Agricultural Experiment Station sweet potatoes yielded an increase of about 18 bushels per acre, due to the effect of crimson clover, a gain equal to that produced on adjoining plats by the addition of 160 pounds of nitrate of soda.

In addition to its value as a green manure, crimson clover is also important as a cover crop, tending to prevent the leaching and washing of soils, especially on hilly land. As a cover crop it is much employed in orchards.

For the improvement of poor lands in the Middle Atlantic region there is no better plan than to use crimson clover as a winter crop and cowpeas as a summer crop. One farmer who adopted this plan succeeded in raising 35 bushels of wheat per acre on land that had never before yielded more than 16 bushels.

SWEET CLOVER.

Sweet clover (fig. 10) is a biennial plant, somewhat weedy in character, which grows readily on almost all soils. It produces an enormous root, and the tops often grow to a height of 4 or 5 feet. Owing to the bitter character of the herbage it is not much liked by stock, which have to learn to eat it. In a few sections of the country it is grown as a hay crop. As a crop, sweet clover is most largely grown in Alabama and Mississippi, where it is utilized both for hay and for its improvement of the soil. It is considered at least equal to red clover for the latter purpose.

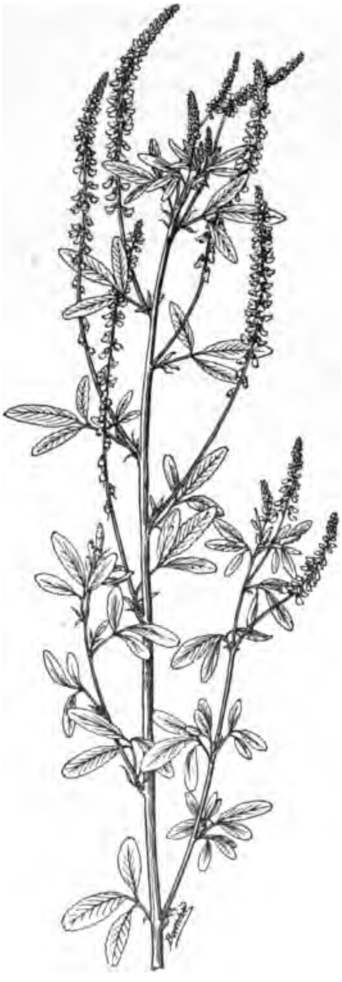


FIG. 10.—Sweet clover.

Owing to the ability of sweet clover to grow in the poorest of soils, it will probably be found of high value in increasing their fertility. The seed should be planted very early in the spring, using about three-fourths of a bushel of the seed in the pod, the common form in which it is found on the market. The greatest benefit will be found in plowing it under the second season, before it blooms.

In an experiment conducted at a German agricultural experiment station sweet clover was sown in May with rye, seeding at the rate of 21 pounds of hulled seed per acre. The following summer the sweet clover was plowed under and followed with oats. The yield was 1,099 pounds per acre on plats where no sweet clover had been sown and 1,645 pounds per acre where sweet clover had been used.

CANADA PEAS.

Canada peas (fig.11) are grown mainly in the northernmost States and in Canada. As a winter green-manure crop in orchards they have been used considerably of late years in California. Very few accurate experiments have been conducted to determine the effect of Canada peas upon succeeding crops. In one such experiment conducted at the Ontario Agricultural College wheat was grown on three different plats on which peas, rape, and buckwheat, respectively, had been plowed under. The yield of wheat following Canada peas was $36\frac{1}{10}$ bushels; following rape, $30\frac{2}{5}$ bushels; following buckwheat, $26\frac{3}{5}$ bushels. There is here a clear gain shown in favor of the Canada peas. The impression prevails among farmers in the Canada pea belt of Michigan that oats following Canada peas yield an increase of from 5 to 10 bushels per acre, but there are no accurate experiments to substantiate this. At the Maine Agricultural Experiment Station oats were sown on some plats following Canada peas and on others following barley. On three out of four plats the yield of oats was larger following barley than following the peas, and the total of all the plats was much in favor of those that had been in barley the previous year. No mention is made as to whether the peas were tubercled or not.

In a series of rotation tests at the South Dakota Agricultural Experiment Station, extending over seven years, the effect of Canada peas on the wheat was to increase slightly the yield of straw without at all increasing the quantity of grain. Practically identical results were obtained on four different plats where peas preceded wheat. The largest increase of straw was obtained where the peas had been pastured off by hogs. No benefit was observed on one plat where the whole pea crop was plowed under. No notes are published as to whether the peas were tubercled or not.

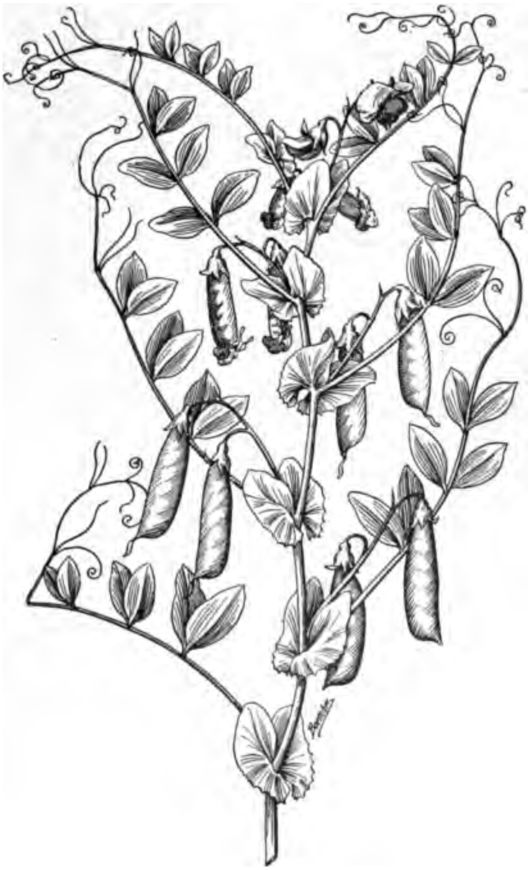


FIG. 11.—Canada pea.

At the present time Canada peas are perhaps more used than any other legume in the citrus orchards in California. The effect is very satisfactory so far as improving the tilth of the soil and its ability to retain water are concerned. There are no accurate data available, however, as to the effect on the crop of fruit, but it is generally believed to be very favorable.

VETCHES.

Two vetches in particular are cultivated in the United States, the common vetch, or tares, and the hairy, or Russian, vetch. The former is much used as a winter crop for hay on the Pacific coast and in the Southern States, being commonly sown with oats, rye, or wheat. It is also extensively grown in the citrus orchards of California as a winter green-manure crop. In the Northern States it is very likely to winterkill.

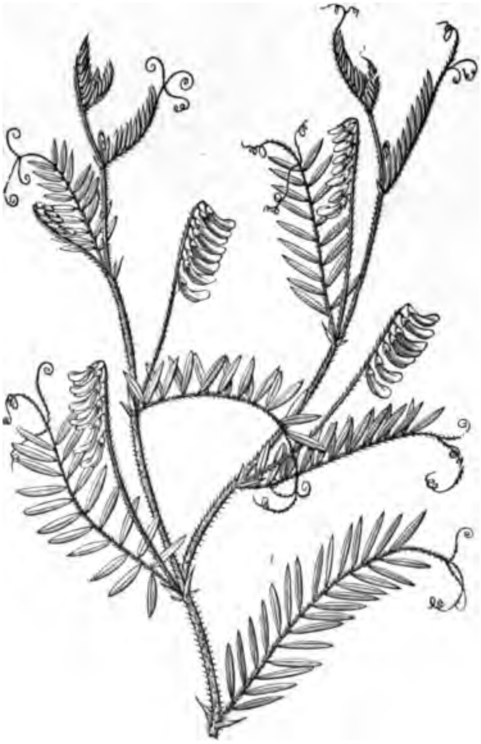


FIG. 12.—Hairy vetch.

Hairy vetch (fig. 12) is in a general way like common vetch, but decidedly more resistant to cold. It will ordinarily survive the winter in most parts of the United States and in Canada. In fact it is more resistant to cold than any other annual legume grown. On this account it is particularly valuable in the North. In the Connecticut Valley it has received much favor as a winter green-manure and cover crop on tobacco lands. Where the winter temperature is not cool enough to prevent growing, as in California, it has been found that hairy vetch grows much more slowly in cool weather than the common vetch, and the latter is therefore preferred. Hairy vetch, however, grows very rapidly as the weather becomes warm.

Vetches are somewhat objectionable where small grains are used in rotation, as they become somewhat weedy in grain fields. Except for this, vetches are a very valuable crop and deserve much more extensive cultivation.

TANGIER PEAS.

The Tangier pea (fig. 13) is a native of northern Africa and has been tested quite extensively in California during the past few years. The plant in a general way resembles the garden sweet pea. In comparison with other legumes in California, the Tangier pea has given the largest yields per acre. This pea is also characterized by its ability to form a very dense covering on the ground, so as to choke out weeds almost perfectly. Indeed, no other legume tested on weedy land in California at all equals the Tangier pea in this respect. No experiments have yet been conducted to determine the effect of the Tangier pea when used as a green-manure crop, but from the numerous large tubercles found on the roots, as shown in figure 14, there is little doubt that it will prove exceedingly valuable in this respect. The hay is eaten readily by horses, and it is believed that the crop will become important.

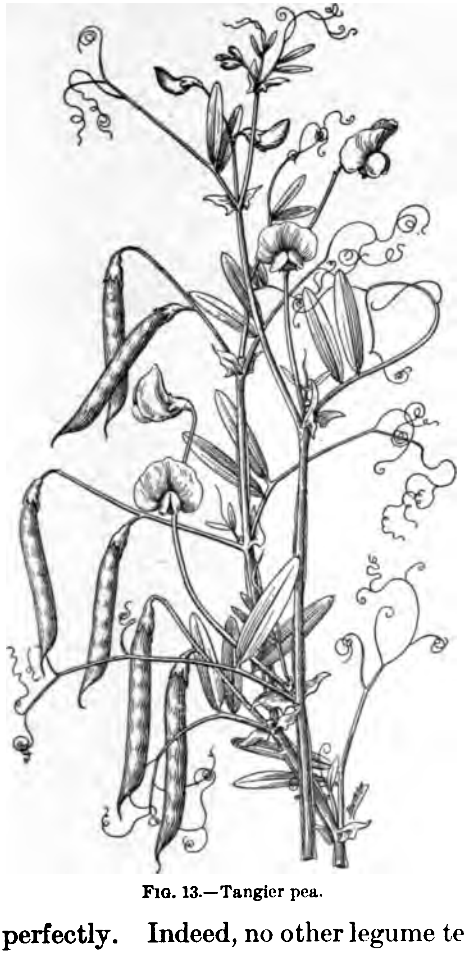


FIG. 13.—Tangier pea.

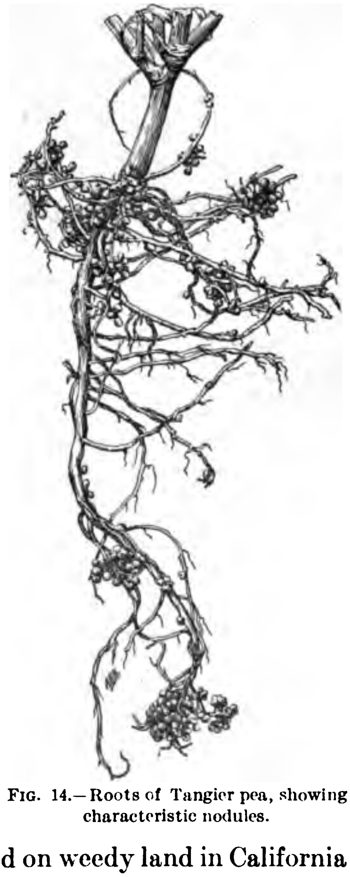


FIG. 14.—Roots of Tangier pea, showing characteristic nodules.

FARMERS' BULLETINS.

The following is a list of the Farmers' Bulletins available for distribution, showing the number, title, and size in pages of each. Copies will be sent free to any address in the United States on application to a Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

22. The Feeding of Farm Animals. Pp. 40.
24. Hog Cholera and Swine Plague. Pp. 16.
25. Peanuts: Culture and Uses. Pp. 24.
27. Flax for Seed and Fiber. Pp. 16.
28. Weeds and How to Kill Them. Pp. 30.
29. Souring and Other Changes in Milk. Pp. 22.
30. Grape Diseases on the Pacific Coast. Pp. 15.
32. Silos and Silage. Pp. 30.
33. Peach Growing for Market. Pp. 24.
34. Meats: Composition and Cooking. Pp. 31.
35. Potato Culture. Pp. 24.
36. Cotton Seed and Its Products. Pp. 16.
39. Onion Culture. Pp. 30.
41. Fowls: Care and Feeding. Pp. 24.
42. Facts About Milk. Pp. 32.
44. Commercial Fertilizers. Pp. 38.
46. Irrigation in Humid Climates. Pp. 27.
47. Insects Affecting the Cotton Plant. Pp. 32.
48. The Manuring of Cotton. Pp. 16.
49. Sheep Feeding. Pp. 24.
51. Standard Varieties of Chickens. Pp. 48.
52. The Sugar Beet. Pp. 48.
54. Some Common Birds. Pp. 48.
55. The Dairy Herd. Pp. 30.
56. Experiment Station Work—I. Pp. 30.
58. The Soy Bean as a Forage Crop. Pp. 24.
59. Bee Keeping. Pp. 48.
60. Methods of Curing Tobacco. Pp. 24.
61. Asparagus Culture. Pp. 40.
62. Marketing Farm Produce. Pp. 31.
63. Care of Milk on the Farm. Pp. 40.
64. Ducks and Geese. Pp. 55.
65. Experiment Station Work—II. Pp. 32.
66. Meadows and Pastures. Pp. 30.
68. The Black Rot of the Cabbage. Pp. 22.
69. Experiment Station Work—III. Pp. 32.
70. Insect Enemies of the Grape. Pp. 23.
71. Essentials in Beef Production. Pp. 24.
72. Cattle Ranges of the Southwest. Pp. 32.
73. Experiment Station Work—IV. Pp. 32.
74. Milk as Food. Pp. 39.
77. The Liming of Soils. Pp. 24.
78. Experiment Station Work—V. Pp. 32.
79. Experiment Station Work—VI. Pp. 27.
80. The Peach Twig-borer. Pp. 16.
81. Corn Culture in the South. Pp 24.
82. The Culture of Tobacco. Pp. 22.
83. Tobacco Soils. Pp. 23.
84. Experiment Station Work—VII. Pp. 32.
85. Fish as Food. Pp. 32.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
91. Potato Diseases and Treatment. Pp. 15.
92. Experiment Station Work—IX. Pp. 30.
93. Sugar as Food. Pp. 31.
95. Good Roads for Farmers. Pp. 46.
96. Raising Sheep for Mutton. Pp. 48.
97. Experiment Station Work—X. Pp. 32.
98. Suggestions to Southern Farmers. Pp. 48.
99. Insect Enemies of Shade Trees. Pp. 30.
100. Hog Raising in the South. Pp. 40.
101. Millets. Pp. 30.
102. Southern Forage Plants. Pp. 48.
103. Experiment Station Work—XI. Pp. 30.
104. Notes on Frost. Pp. 24.
105. Experiment Station Work—XII. Pp. 32.
106. Breeds of Dairy Cattle. Pp. 48.
107. Experiment Station Work—XIII. Pp. 32.
108. Saltbushes. Pp. 20.
109. Farmers' Reading Courses. Pp. 20.
110. Rice Culture in the United States. Pp. 28.
111. Farmer's Interest in Good Seed. Pp. 24.
112. Bread and Bread Making. Pp. 40.
113. The Apple and How to Grow It. Pp. 32.
114. Experiment Station Work—XIV. Pp. 28.
115. Hop Culture in California. Pp. 28.
116. Irrigation in Fruit Growing. Pp. 48.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 30.
120. Insects Affecting Tobacco. Pp. 32.
121. Beans, Peas, and other Legumes as Food. Pp. 38.
122. Experiment Station Work—XVI. Pp. 32.
124. Experiment Station Work—XVII. Pp. 32.
125. Protection of Food Products from Injurious Temperatures. Pp. 24.
126. Practical Suggestions for Farm Buildings. Pp. 48.
127. Important Insecticides. Pp. 46.
128. Eggs and Their Uses as Food. Pp. 40.
129. Sweet Potatoes. Pp. 40.
131. Household Tests for Detection of Oleomargarine and Renovated Butter. Pp. 10.
132. Insect Enemies of Growing Wheat. Pp. 38.
133. Experiment Station Work—XVIII. Pp. 32.
134. Tree Planting in Rural School Grounds. Pp. 32.
135. Sorghum Sirup Manufacture. Pp. 40.
136. Earth Roads. Pp. 24.
137. The Angora Goat. Pp. 48.
138. Irrigation in Field and Garden. Pp. 40.
139. Emmer: A Grain for the Semiarid Regions. Pp. 16.
140. Pineapple Growing. Pp. 48.
141. Poultry Raising on the Farm. Pp. 16.
142. Principles of Nutrition and Nutritive Value of Food. Pp. 48.
143. Conformation of Beef and Dairy Cattle. Pp. 44.
144. Experiment Station Work—XIX. Pp. 32.
145. Carbon Bisulphid as an Insecticide. Pp. 28.
146. Insecticides and Fungicides. Pp. 16.
147. Winter Forage Crops for the South. Pp. 40.
148. Celery Culture. Pp. 32.
149. Experiment Station Work—XX. Pp. 32.
150. Clearing New Land. Pp. 24.
151. Dairying in the South. Pp. 48.
152. Scabies in Cattle. Pp. 32.
153. Orchard Enemies in the Pacific Northwest. Pp. 39.
154. The Home Fruit Garden: Preparation and Care. Pp. 16.
155. How Insects Affect Health in Rural Districts. Pp. 19.
156. The Home Vineyard. Pp. 22.
157. The Propagation of Plants. Pp. 24.
158. How to Build Small Irrigation Ditches. Pp. 28.
159. Scab in Sheep. Pp. 48.
161. Practical Suggestions for Fruit Growers. Pp. 30.
162. Experiment Station Work—XXI. Pp. 32.
164. Rape as a Forage Crop. Pp. 16
165. Silkworm Culture. Pp. 32.
166. Cheese Making on the Farm. Pp. 16.
167. Cassava. Pp. 32.
168. Pearl Millet. Pp. 16.
169. Experiment Station Work—XXII. Pp. 32.
170. Principles of Horse Feeding. Pp. 44.
172. Scale Insects and Mites on Citrus Trees. Pp. 43.
173. Primer of Forestry. Pp. 48.
174. Broom Corn. Pp. 30.
175. Home Manufacture and Use of Unfermented Grape Juice. Pp. 16.
176. Cranberry Culture. Pp. 20.
177. Squab Raising. Pp. 32.
178. Insects Injurious in Cranberry Culture. Pp. 32.
179. Horseshoeing. Pp. 30.
181. Pruning. Pp. 39.

182. Poultry as Food. Pp. 40.
183. Meat on the Farm: Butchering, Curing, and Keeping. Pp. 37.
184. Marketing Live Stock. Pp. 40.
185. Beautifying the Home Grounds. Pp. 24.
186. Experiment Station Work—XXIII. Pp. 32.
187. Drainage of Farm Lands. Pp. 38.
188. Weeds Used in Medicine. Pp. 45.
190. Experiment Station Work—XXIV. Pp. 32.
192. Barnyard Manure. Pp. 32.
193. Experiment Station Work—XXV. Pp. 32.
194. Alfalfa Seed. Pp. 14.
195. Annual Flowering Plants. Pp. 48.
196. Usefulness of the American Toad. Pp. 16.
197. Importation of Game Birds and Eggs for Propagation. Pp. 30.
198. Strawberries. Pp. 24.
199. Corn Growing. Pp. 32.
200. Turkeys. Pp. 40.
201. Cream Separator on Western Farms. Pp. 23.
202. Experiment Station Work—XXVI. Pp. 32.
203. Canned Fruits, Preserves, and Jellies. Pp. 32.
204. The Cultivation of Mushrooms. Pp. 24.
205. Pig Management. Pp. 40.
206. Milk Fever and Its Treatment. Pp. 16.
208. Varieties of Fruits Recommended for Planting. Pp. 48.
209. Controlling the Boll Weevil in Cotton Seed and at Ginneries. Pp. 32.
210. Experiment Station Work—XXVII. Pp. 32.
211. The Use of Paris Green in Controlling the Cotton Boll Weevil. Pp. 23.
213. Raspberries. Pp. 38.
215. Alfalfa Growing. Pp. 40.
216. The Control of the Boll Weevil. Pp. 32.
217. Essential Steps in Securing an Early Crop of Cotton. Pp. 16.
218. The School Garden. Pp. 40.
219. Lessons from the Grain Rust Epidemic of 1904. Pp. 24.
220. Tomatoes. Pp. 32.
221. Fungous Diseases of the Cranberry. Pp. 16.
222. Experiment Station Work—XXVIII. Pp. 32.
223. Miscellaneous Cotton Insects in Texas. Pp. 24.
224. Canadian Field Peas. Pp. 16.
225. Experiment Station Work—XXIX. Pp. 32.
226. Relation of Coyotes to Stock Raising in the West. Pp. 24.
227. Experiment Station Work—XXX. Pp. 32.
228. Forest Planting and Farm Management. Pp. 22.
229. The Production of Good Seed Corn. Pp. 24.
231. Spraying for Cucumber and Melon Diseases. Pp. 24.
232. Okra: Its Culture and Uses. Pp. 16.
233. Experiment Station Work—XXXI. Pp. 32.
234. The Guinea Fowl. Pp. 24.
235. Preparation of Cement Concrete. Pp. 32.
236. Incubation and Incubators. Pp. 32.
237. Experiment Station Work—XXXII. Pp. 32.
238. Citrus Fruit Growing in the Gulf States. Pp. 48.
239. The Corrosion of Fence Wire. Pp. 32.
240. Inoculation of Legumes. Pp. 8.
241. Butter Making on the Farm. Pp. 32.
242. An Example of Model Farming. Pp. 16.
243. Fungicides and their Use in Preventing Diseases of Fruits. Pp. 32.
244. Experiment Station Work—XXXIII. Pp. 32.
245. Renovation of Worn-out Soils. Pp. 16.
246. Saccharine Sorghums for Forage. Pp. 37.
247. The Control of the Codling Moth and Apple Scab. Pp. 21.
248. The Lawn. Pp. 20.
249. Cereal Breakfast Foods. Pp. 36.
250. The Prevention of Wheat Smut and Loose Smut of Oats. Pp. 16.
251. Experiment Station Work—XXXIV. Pp. 32.
252. Maple Sugar and Sirup. Pp. 36.
253. The Germination of Seed Corn. Pp. 16.
254. Cucumbers. Pp. 30.
255. The Home Vegetable Garden. Pp. 47.
256. Preparation of Vegetables for the Table. Pp. 48.
257. Soil Fertility. Pp. 39.
258. Texas or Tick Fever and Its Prevention. Pp. 45.
259. Experiment Station Work—XXXV. Pp. 32.
260. Seed of Red Clover and Its Impurities. Pp. 24.
261. The Cattle Tick. Pp. 22.
262. Experiment Station Work—XXXVI. Pp. 32.
263. Practical Information for Beginners in Irrigation. Pp. 40.
264. The Brown-tail Moth and How to Control It. Pp. 22.
265. Game Laws for 1906. Pp. 54.
266. Management of Soils to Conserve Moisture. Pp. 30.
267. Experiment Station Work—XXXVII. Pp. 32.
268. Industrial Alcohol: Sources and Manufacture. Pp. 45.
269. Industrial Alcohol: Uses and Statitises. Pp. 29.
270. Modern Conveniences for the Farm Home. Pp. 48.
271. Forage Crop Practices in Western Oregon and Western Washington. Pp. 39.
272. A Successful Hog and Seed-Corn Farm. Pp. 16.
273. Experiment Station Work—XXXVIII. Pp. 32.
274. Flax Culture. Pp. 36.
275. The Gypsy Moth and How to Control It. Pp. 22.
276. Experiment Station Work—XXXIX. Pp. 32.
277. The Use of Alcohol and Gasoline in Farm Engines. Pp. 40.
278. Leguminous Crops for Green Manuring.
279. A Method of Eradicating Johnson Grass. (In press.)
280. A Profitable Tenant Dairy Farm. (In press.)
281. Experiment Station Work—XL. (In press.)
282. Celery. (In press.)
283. Spraying for Apple Diseases and the Codling Moth in the Ozarks. (In press.)
284. Insect and Fungous Enemies of the Grape East of the Rocky Mountains. (In press.)
285. The Advantage of Planting Heavy Cotton Seed. (In press.)
286. Comparative Value of Whole Cotton Seed and Cotton Seed Meal in Fertilizing Cotton. (In press.)
287. Poultry Management. (In press.)
288. Nonsaccharine Sorghums. (In press.)
289. Beans. (In press.)

O

Issued April 5, 1907.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 279.

A METHOD OF ERADICATING JOHNSON GRASS.

BY

J. S. CATES,
Scientific Assistant,

AND

W. J. SPILLMAN,
Agriculturist in Charge of Farm Management Investigations,
Bureau of Plant Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., January 30, 1907.

Sir: I have the honor to transmit herewith a paper describing method of exterminating Johnson grass, and respectfully recommen that it be published as a Farmers' Bulletin. This paper was prepare jointly by Mr. J. S. Cates and Mr. W. J. Spillman, of this Bureau who have conducted investigations on this subject for several year past. The facts stated make it clear that the rootstock habits of thi grass are such as to render it comparatively easy to destroy the pes when proper advantage is taken of them.

Acknowledgments are due to Mr. J. J. Harrison, of Columbus, Tex. for valuable assistance in the conduct of the experiments treated o in this paper. The experiments were conducted on his farm, an his interest in the work enabled the Department to secure importan results at comparatively slight expense.

Respectfully,
B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

B. P. I.—260.

A METHOD OF ERADICATING JOHNSON GRASS.

INTRODUCTION.

In Bulletin No. 72, Part III, of the Bureau of Plant Industry,[a] the results of experiments in the extermination of Johnson grass on the farm of Mr. J. B. Gay, Columbus, Tex., planned by one of the writers and conducted by Mr. Gay, were outlined. Those investigations were begun in the autumn of 1902. In order to secure the most difficult conditions and thus to render any results obtained of the greatest value, a plat of land for the experimental work was chosen in an abandoned area near the center of a large field badly infested with this pest. It was supposed that if Johnson grass could be eradicated on this land, from which hay had been cut for two or three years, it could be more easily eradicated on land in which the grass was not so thickly set. As stated in the bulletin referred to, several of the methods tried were entirely successful, and cotton has since been grown on this land practically free from Johnson grass.

The method which gave best results was to plow the land in the fall, and then, by means of some such implement as a grass hoe, to remove the rootstocks from the soil. The land was treated twice with this implement, and it was estimated that the rootstocks removed from each acre weighed about a ton. On most of the land no further special treatment was given. Part of it was summer-fallowed the next summer, and on this part every sprig of Johnson grass was killed. On the remainder of the land a few sprigs of the grass grew the next year, but they were so few that even three years later the grass was not troublesome.

When those experiments were conducted it was impossible to find the time necessary to make a careful study of the rootstock habits of Johnson grass in all kinds of soil and under all conditions. It was felt, however, that this was a matter of great importance, and it was believed that such a study might result in knowledge which would greatly simplify the methods required for exterminating Johnson grass. These expectations have been fully realized.

In July, 1905, Mr. J. S. Cates was employed to devote his whole time to these studies until the problem could be solved. The experiments the results of which are detailed in this bulletin are those conducted by Mr. Cates since that time. As a result of a careful study of the rootstock habits of this grass and experiments based upon the knowledge thus acquired, it has been fully demonstrated that the use of a root puller may be dispensed with, and it is now nearly certain that the earlier experiments would have produced practically the same results if the pulling of the roots had been omitted.

---

[a] Spillman, William J. Extermination of Johnson Grass. 1905.

ROOTSTOCK HABITS OF JOHNSON GRASS.

The following points concerning what may be called the agronomic life history of Johnson grass, or variations in its habits under different field conditions, have been determined. It is believed now that a knowledge of all of them is essential in intelligently combating the plant when it is a pest. As those acquainted with this grass are fully aware, the underground stems,[a] or rootstocks, are the source of most of the trouble. The study in which we are therefore most interested is that of these rootstocks. They may be classified as primary, secondary, and tertiary.

In this classification primary rootstocks embrace all the rootstocks alive in the ground at the beginning of the growing season in spring.

Secondary rootstocks are those which arise from the primaries, come to the surface, and there form crowns, thus producing new plants.

A tertiary rootstock is one starting later in the season, about flowering time, from the base of the crown of this new plant.

These tertiary rootstocks, when the ground is soft, and especially when a large top is allowed to develop, grow to a large diameter and penetrate to a great depth, sometimes as much as 4 feet, and normally from 15 to 30 inches; at other times, when the soil is compact, and especially when the plant above ground is not allowed to develop by
of mowing or grazing, or both, these tertiary rootstocks grow
ll diameter and run along just under the surface, cropping
to form new plants. Our observations indicate that
cks (i. e., those that were in the ground at the
ng season in spring) all decay in the fall, after
. Their strength has been taken up in the
otstocks and above-ground growth. In
ks do not live over a second winter.
and tertiaries) do this. Secondary
diameter than the primary root-
heir length is determined by the
s are buried. Secondary root-
laries from their joints. These

---

etween these underground stems, or root-
rom roots in that they are jointed, like stems,
ths at the joints.

branches of the secondaries, however, are usually directed, like the parent stem, toward the surface, and they may therefore be included with the secondaries. The secondaries are especially likely to branch if the top formed above ground has been destroyed. Under our classification secondary and tertiary rootstocks become primary rootstocks at the beginning of the next season after their formation, and they, in their turn, send out secondary growth to reach the surface; the plant formed at the surface then sends out from the base of its crown, about the time it blossoms, large deep-burrowing tertiary rootstocks which, in the soft land of the cultivated cotton and corn fields, cause much mischief the following year. *The longer the plants are allowed to stand after blossoming, the larger and deeper these tertiary stems become.*

The habits of the plant with reference to the formation of these underground parts vary widely under different field conditions, particularly with reference to this tertiary rootstock growth sent out late in the season. There are four very distinct types of rootstock development found on the ordinary farm, the type of the rootstock being determined by the way the land has been cropped. These four types of rootstock development may be defined as follows.

TYPES OF ROOTSTOCK DEVELOPMENT.

(1) On corn or cotton land poorly cultivated during the early growing season, particularly on corn land, which is never cultivated so carefully as cotton land, the grass is not killed, but is allowed to grow up luxuriantly after cultivation has ceased. In this soft soil, after cultivation has stopped, a large top is soon produced, the plant flowers and matures seed, and these tertiary rootstocks bore down to a great depth and develop to a large diameter. Figure 1 shows a cross section of this kind of land, with the tertiary rootstocks ranging deep into the the soil, photographed in November, 1906, at Columbus, Tex. In this illustration, which was obtained by carefully digging away the dirt and leaving the rootstocks exposed, these stems are 20 inches in depth, and in some cases they grow much deeper than this. This is considered the very worst type of Johnson grass land, as these deep rootstocks contain a large amount of nutriment, and, even though the surface plants be kept closely cut by cultivation, they can continue to send up growth, usually until the latter part of August. As the soil warms up with the advancing season on cultivated land the rootstocks sprout out from greater and greater depths. The secondary rootstocks were noted during the past season sprouting out from a depth of more than 20 inches beneath the surface.

(2) Figure 2 shows a cross section of a piece of land adjoining that illustrated in figure 1. The land in both cases was cultivated in corn during the season of 1905, that part shown in figure 2 having been pas-

tured during the season of 1906, while that shown in figure 1 was cultivated in cotton. The plant illustrated in figure 1 was not destroyed by the cultivation, and in the latter part of the season sent out the growth shown. The land shown in figure 2 was pastured rather closely. It will be noted that the new growth (fig. 2) is a small plant that has sent out tertiary rootstocks only 2 inches or so beneath the soil. There is but little secondary growth, as only the upper part of the old tertiary rootstock put forth growth in this compact soil. Ranging across the picture and reaching to a greater depth is shown the old 1905 rootstock. This is in a state of decay throughout.

The tendency of the Johnson grass plant seems to be to form seed before making very much tertiary growth. If it is kept closely cropped and not allowed to develop very much above ground, there will be but little growth beneath the surface, although some tertiary development will be made in the latter part of the season, whether the plant is allowed to form seed or not. The depth to which this tertiary growth will penetrate depends also somewhat on the compactness of the soil. It has been noticed in land cultivated the preceding year, left in ridges and then pastured the following season that the small rootstocks produced have a tendency to grow at rather uneven depths, burrowing deeper in the soft ridges than they do in the spaces between the rows. This occasions trouble in devising a cultural method to destroy the plant. It would therefore be advisable in turning out land for pasture to first level it off by some means. On land which is to be mown the advantage of having it smooth is obvious.

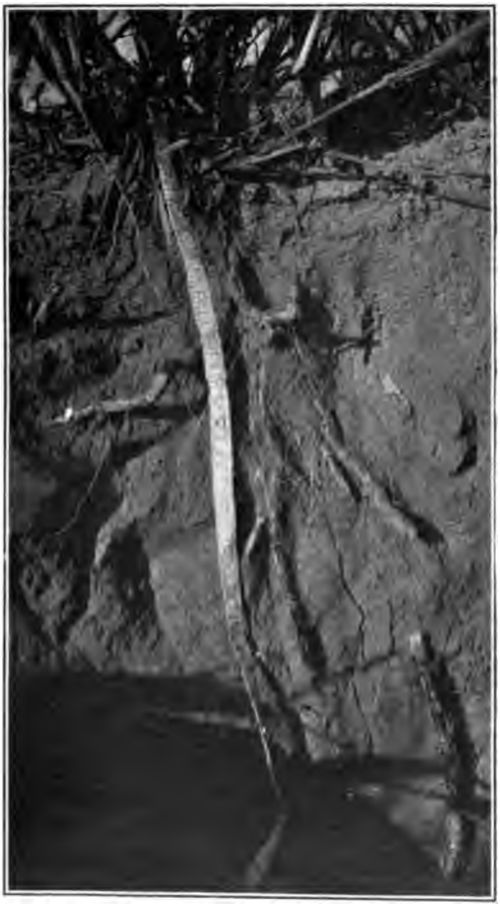


FIG. 1.—Cross section showing deep development of rootstock of Johnson grass found in late summer in a poorly cultivated corn or cotton field.

(3) The third type of rootstock development is shown in figure 3. This is meadow land which was "broken broadcast" in March, 1906, and the cross section was photographed the following June. It is a common practice, in order to secure the best yield of hay, to break land in spring at least every two years. On this freshly broken land the rootstocks develop in a rather thick mat to the depth to which the land has been broken. In the illustration the ground seems thickly set with rootstocks to a depth of about 8 inches. These are, for the most part, secondary rootstocks. The small rootstocks near the surface the preceding year were buried deeply, and the rootstocks shown in the picture are the secondary growth sent out to reach the surface. This land would be very troublesome if an attempt were made to grow a cultivated crop another season.

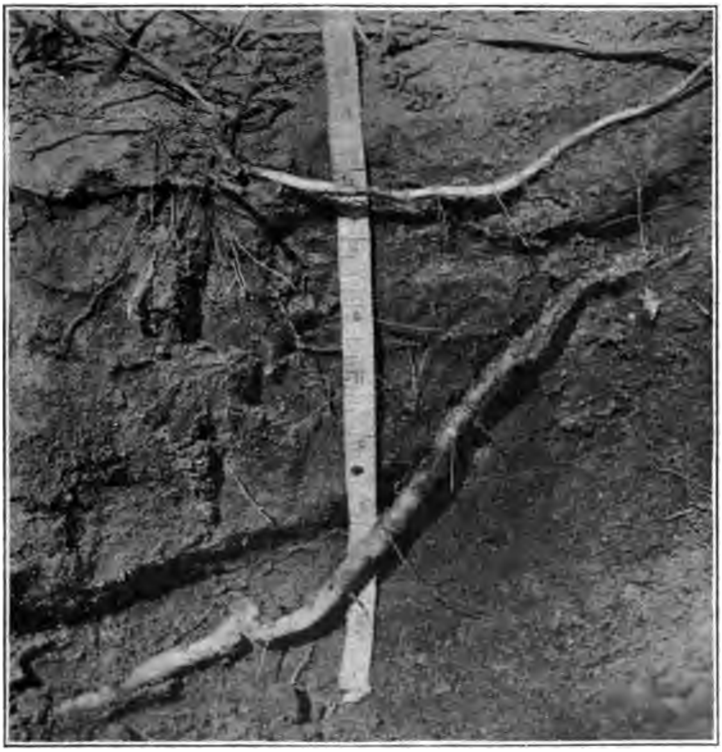


FIG. 2.—Cross section showing small and shallow rootstock development of Johnson grass, as commonly found in closely pastured land.

(4) In figure 4 is shown a section of the same piece of land, which was not plowed in the spring. The photograph was taken at the same time as that used for figure 3. The old rootstock from which the plant seen in the illustration sprang is not evident. It has been absorbed in making the new plant and has rotted away. This old primary rootstock was so near the surface that there is little or no secondary growth. The

little white stems starting out from the base of the crown of the plant are new tertiary rootstocks. On this hard land, however, and especially if it is kept mowed regularly, they are not likely to penetrate to any great depth or to attain a very great diameter.

These are the four most common field conditions under which Johnson grass occurs throughout the Southwestern States. As might readily be surmised, in conditions like those shown in figures 2 and 4 the pest can be very readily controlled. Where the rootstocks have attained such development, however, as is shown in figures 1 and 3, it is only by the most persistent and careful cultivation that the grass can be destroyed, and then at a cost which makes questionable the advisability of attempting its destruction. That the grass can be killed fairly easily when it has attained the state shown in figures 2 and 4 has not only been demonstrated by the experience of the writers, but has been substantiated by observations and interviews with many careful farmers throughout the Johnson grass infested country. Observations to date have failed to show any rootstocks remaining over in a fairly sound state for more than one year after their formation. This point, however, is not considered as entirely settled, for if a very dry season follows a season during which a deep rootstock is produced, then it seems possible that this rootstock may be preserved through the second winter, although none of this kind have yet been found.

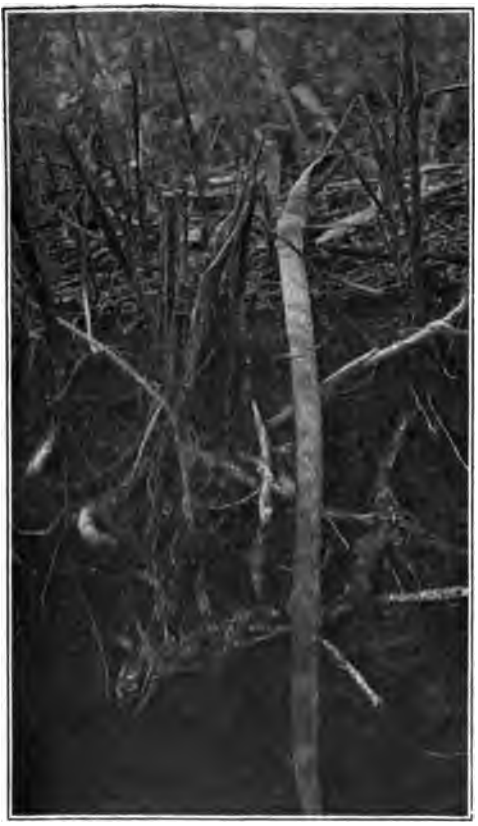


FIG. 3.—Cross section showing the large growth of secondary rootstocks of Johnson grass when an old sod is plowed deep in the spring.

METHOD OF ERADICATION BASED ON ROOTSTOCK HABITS.

In order to kill easily an old Johnson grass meadow or pasture by cultivation in hoed crops, the land should be broken very shallow. If two shallow rootstock sods are plowed, one deep and the other shallow, the buried rootstocks in both cases will send out jointed secondary stocks to reach the surface. Now, obviously, in the case of the rootstocks buried deeply, a large part of their substance is turned into the secondary rootstocks to connect with the new surface plant, while in the case of those buried shallow there is no opportunity for the plant to form a long secondary rootstock, only a small part goes into this secondary growth, and the main substance of the rootstock goes directly into the plant formed above ground. As the growth above ground is very easily killed, while the secondary growth is as troublesome as the primary rootstocks, it is clear that we should break this pasture or sod land very shallow and attempt to keep the rootstocks as near the surface as possible in order that the substance may go directly into the above-ground plant instead of into this secondary growth. Although the breaking be shallow the work should be carefully done, and it is best to rebreak in order to stimulate the growth from the primary rootstocks early in the season. By this means the old rootstocks are soon exhausted. If there is a convenient time in late summer this shallow plowing is very effective then.

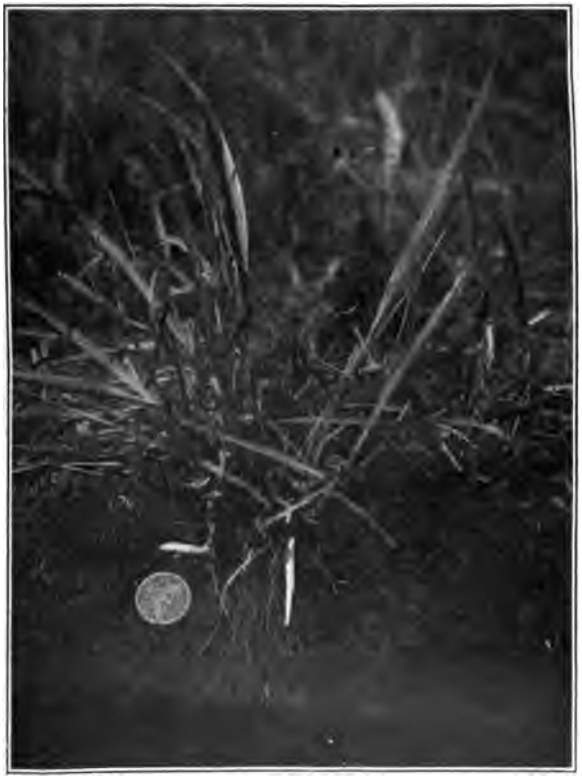


Fig. 4.—Cross section showing small tertiary growth and practically no secondary growth of Johnson grass on an old sod which has not been broken for several years.

Numerous instances have been reported of killing Johnson grass sod by shallow plowing during the dry part of the summer. If the climate is such that there are many alternate freezes and thaws during the winter, shallow winter breaking will be effective, while if both summer and winter treatments fail, or if it be more convenient, the work may be put off until early spring when, if it be carefully done, it is very effective. The main point is to induce this shallow rootstock system, and then, in breaking, to keep these rootstocks near the surface where they can be reached by summer sun or winter freezing; or, if the work be delayed until spring, so that the secondary rootstock growth will amount to but little, then by close cultivation to destroy the young plant before it starts the formation of the tertiary rootstocks, which start just about the time the plant begins to form a flowering head.

EXPERIMENTAL RESULTS.

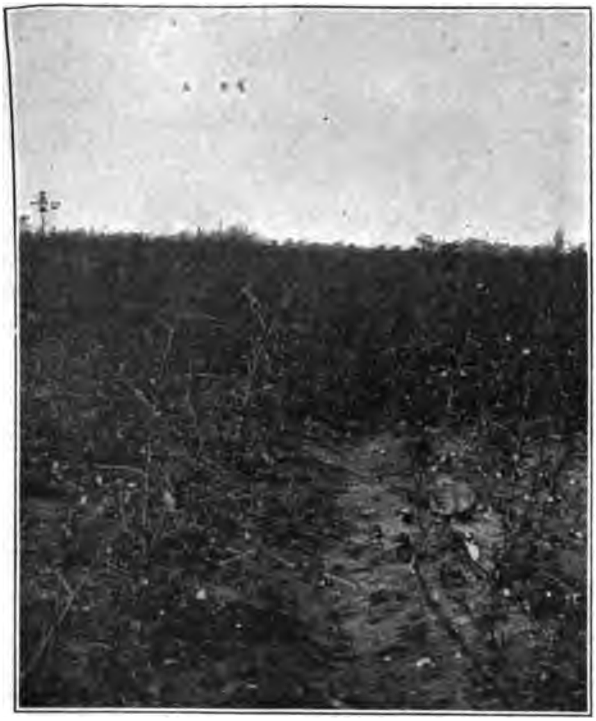


FIG. 5.—The junction line between the two sections of a field of cotton, part in corn and part in Johnson grass sod the previous year. The clean land was in Johnson grass sod.

An experiment was conducted on the farm of Mr. J. J. Harrison, Columbus, Tex., which illustrates clearly the greater ease with which Johnsongrass can be killed where it has attained this slight rootstock development as compared with cases where the rootstocks penetrate deeply. A large body of land was thoroughly infested with Johnson grass. A fence was run across one section of this land in the spring of 1903 and the worst part of the field was turned into a meadow. Hay was mown on this meadow for three years, and in the latter part of the season of 1906 the land was pastured. On the other side of the fence cotton was grown for two years, and in 1905 it was planted to corn. In the spring of 1906 the fence was removed and the whole field was broken in a body again and planted to cotton. This whole section was thickly set in Johnson grass. In the part which had been cultivated to corn the rootstocks had penetrated very deeply, while in the part which had been pastured they were very near the surface. The rows were run at right angles to the old fence line, and both portions of the field were cultivated the same number of times. On the land which had been previously in meadow the Johnson grass was completely killed out and had disappeared long before the cultivation ceased, as is noted in the record below. On the land which was in corn in 1905, little or no headway was made in destroying the grass. The photograph reproduced as figure 5 was taken by placing the camera over a dozen paces on the old pastured land and looking toward the old fence line. The abrupt change from cleared land to grass is shown, with the cleared pastured land in the foreground. Johnson grass higher than the cotton stalks is shown in figure 5, while in figure 7 it will be seen that the ground is practically clean.

The work done on this field was much more than sufficient to kill the grass entirely on the land which had been used for meadow and pasture. The grass was practically destroyed after the second plowing and chopping; but, as shown in the illustration (fig. 5), after all the cultivation the grass on the land previously in corn was very little affected. The following is a record of the work done in raising the crop on this field for the season of 1906:

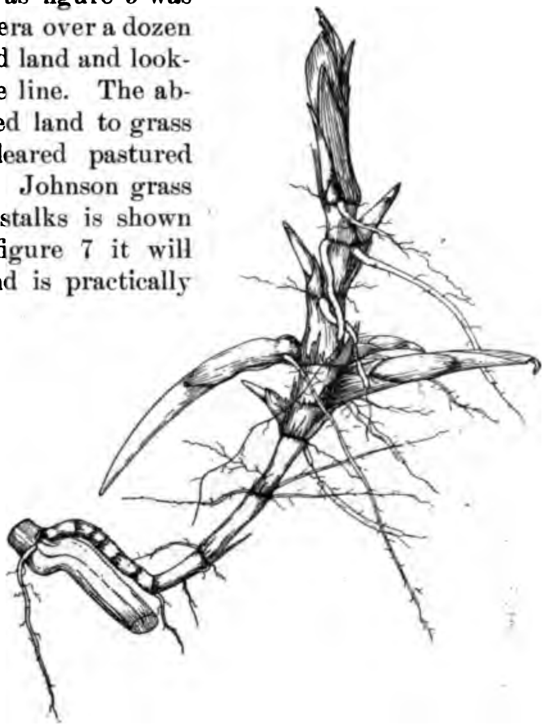


FIG. 6.—Sprig of Johnson grass rootstock left by a careless chopper.

Bedded and rebedded February 4 (common turning plow).
Planted March 30 (ridge opened with sweep, and seed put in with planter).
Plowed April 14 (single sweeps).
Chopped and plowed April 28 (single sweeps). (Grass practically destroyed on pastured end of field.)
Chopped and plowed May 26 (single sweeps).
Chopped June 16.
Chopped and plowed July 28 (riding plow, two 14-inch sweeps).
Middles plowed July 28 (24-inch sweeps).

NECESSITY OF CAREFUL TILLAGE.

Careless hoe work should not be allowed in fighting Johnson grass. This is one of the chief reasons that the pest has made such headway. Figure 6 shows a sprig of Johnson grass which a careless chopper cut off just at the surface of the ground. One good dig would have removed this growth entirely. Instead, however, the plant is but slightly damaged. Branches are starting from the base of the rootstock left in the ground, and the whole plant will be as green as ever in a few days.

Odd corners of the field also should not be allowed to reseed the land for another year. Figure 7 shows a field which early in the season of 1906 was well rid of Johnson grass simply as the result of careful cultivation of the old sod land planted to cotton. The photograph of the same field, shown in figure 8, was taken by reversing the camera and looking toward the fence. It will be noticed that the fence row is thickly set with grass. The seed formed along the fence row will be scattered and cause trouble next year. The grass in such situations should never be allowed to head out.

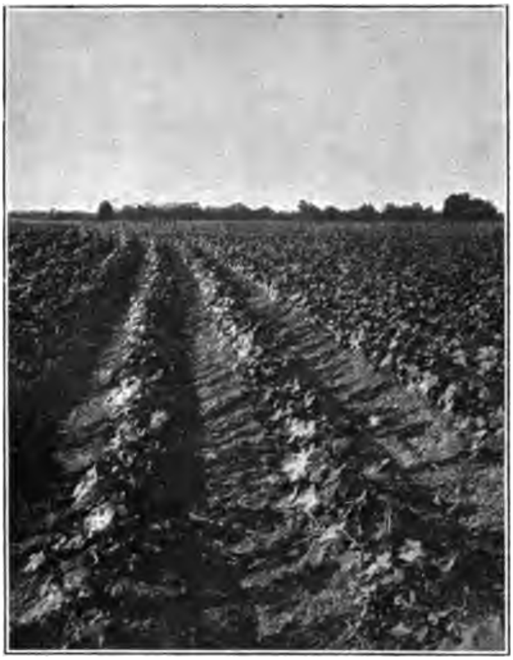


FIG. 7.—Old meadow land cleared of Johnson grass early in the season.

CHEMICAL METHODS OF DESTRUCTION NOT PRACTICAL.

No patented chemical or other preparation for destroying Johnson grass which has been examined has been found to be practical or economical in any way. Those considering the investment of their money in something of this kind will do well to take a second thought. All chemicals for this purpose found on sale in Texas have been tested.

ROTATION WITH WINTER GRAIN.

A simple rotation of winter grain and Johnson grass has advocates in many sections. The sod is broken in the late summer and small grain is sown in the early fall. After the grain is harvested the following spring, two and sometimes three crops of Johnson grass hay can be secured in favorable seasons. In the late summer the land is broken again for small grain. Mr. J. W. Storey, Ennis, Tex., has 20 acres of Johnson grass land on which he raises oats. The oats are sown in October and harvested from the first to the middle of June. After this, three cuttings of Johnson grass hay are made, averaging a ton to a cutting. Mr. Storey reports that his oat crop never falls below 40 bushels per acre, and sometimes reaches 75 bushels. He estimates that about three-fourths as much oats is raised as there would be if there were no Johnson grass. This rotation is also practiced in other sections of Texas and in several other places where Johnson grass is established.

ROTATION WITH CULTIVATED CROPS.

Where the hay has a market value and can be harvested with safety, it may prove profitable to use Johnson grass on infested land in rotation with a cultivated crop. After the Johnson grass has been cut for hay one or two seasons or used for pasture, a cultivated crop may be grown the next year practically free from Johnson grass by exercising a little extra care in preparing the ground and cultivating the crop. Grown in this way the grass will have some renovating effect on the soil, as it aids in keeping up the supply of humus. One should, however, thoroughly convince himself that he is master of methods of controlling or eradicating the grass, and should have considerable experience in clearing it out before introducing it into a regular rotation with cultivated crops. There is usually considerable difficulty in hay making in the Johnson grass belt on account of the uncertain seasons.

FIG. 8.—The field shown in figure 7, but looking in the opposite direction.

In sections where Johnson grass infests practically all the land, there is no question that this grass can be utilized in rotation to excellent advantage somewhat after the manner of timothy in the North. The standard rotation adapted to nearly all parts of the cotton belt, especially on general live stock and cotton farms, is cotton, followed by corn and cowpeas, this by winter grain, after which a crop of cowpeas for hay is grown, thus giving a three-year rotation producing four harvested crops. Johnson grass can be inserted in this rotation after the cowpea crop. It can be used for hay for one year; then pastured a year; or it may be cut for hay for two years, after which the land can be again prepared for cotton and run through the regular rotation. We must repeat, however, that before undertaking to use Johnson grass in this manner the farmer must be sure that he understands how to control it, and we would not advise the sowing of Johnson grass seed on land not already infested.

CUTTING BACK SOMETIMES NECESSARY FOR ERADICATION.

The method of eradicating Johnson grass outlined in this bulletin is based on the fact that when the soil is not disturbed and when the top is not allowed to make much growth, and especially when it is not allowed to stand long after blossoming, the tertiary growth of rootstocks is small and confined to the upper few inches of the soil. This fact enables the farmer to clean out the grass the next year with a little extra care in plowing and cultivating. There are some situations, however, to which this method is not applicable. This is especially true of fence rows, railroad rights of way, ditch banks, vineyards, and other places where it is impracticable to handle the grass in a proper manner. In such cases one must resort either to chemical methods, which are very expensive, or to persistent cutting back, which gives the grass no opportunity to produce tertiary growth. In vineyards and similar situations the grass should invariably be cut back by the time it heads or earlier, if possible, and the closer it is cut back the better. During midsummer, or a little later, all of the top growth should be removed with a hoe, care being used to cut deep enough with the hoe to remove the crown of every plant, and especially to get out any tertiary rootstocks that are beginning to develop. It is probable, though it is not demonstrated, that if the tertiary growth is entirely prevented for two seasons the pest will be well in hand. This, of course, means a great deal of hand work; but where ordinary cultural methods can not be applied the hand work seems necessary.

SUMMARY AND CONCLUSIONS.

A logical method of controlling Johnson grass in the light of these investigations seems to be, in brief, to turn the land into meadow or pasture and keep the grass closely cropped, either by grazing animals upon it or by mowing it for one or more seasons.

Since the development of the tertiary growth becomes quite vigorous about the time the plant begins to blossom, it is a matter of the utmost importance not to allow the grass to stand after blossoming time. After the sod has remained undisturbed for a whole year, it should be plowed shallow, and the subsequent cultivation should be intelligently and efficiently done. If a cultivated field is overrun in large spots with the grass, it would be advisable to sow the whole field and level down the ridges. If the land is already in sod, cut the hay before blossoming every time a growth is thrown up, or, better, pasture it; then flat-break—that is, plow it with an ordinary turning plow—just deep enough to turn up all the rootstocks, which will usually be 3 to 4 inches deep. Plant a cultivated crop and give this crop a little extra cultivation. Any stray shoots of grass that may be seen may be removed by hand about the time the grass heads out. This can be easily done, since the roots will be shallow.

O

Issued April 26, 1907.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 280.

A PROFITABLE TENANT DAIRY FARM.

BY

LYMAN CARRIER,
Scientific Assistant, Farm Management Investigations
Bureau of Plant Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

B. P. I.—262.

A PROFITABLE TENANT DAIRY FARM.

INTRODUCTION.

It is seldom that a tenant farmer pays much attention to increasing soil fertility. Run-down and worn-out farms that have been "worked on shares" in all the old settled sections prove the truth of this statement. A rented farm where both owner and tenant are receiving adequate compensation for their investment and services and where ample returns are made to the soil to insure larger and better yields with each succeeding year should attract more than passing notice. Such conditions exist on a farm located in southern Michigan. It is a dairy farm of 120 acres, of which 106 acres are tillable, 2½ acres are in natural pasture, and the remainder is taken up by lanes, roads, and yards about the buildings.

Prior to October, 1905, the farm and buildings represented an investment by the owner, Mr. J. N. Neal, of $12,500, from which he received a net yearly income of $1,500, or 12 per cent on his investment. The management of the farm occupied none of his attention; he was as free to devote his time to other business matters as if his money had been invested in bonds or mortgages. The tenant-manager, Mr. Charles J. Angevine, has been on the place thirteen years, and to him must be given the credit for the excellent condition of the farm and for the large crops produced.

CONTRACT FOR THE OPERATION OF THIS FARM.

The agreement under which the business is carried on is this: Each man owns half the dairy herd. The manager furnishes the horses and ordinary farm implements, such as plows, wagons, and harrows. Machinery that belongs permanently on the farm, such as engines and silage cutters, and the general expenses of running the place are paid for out of the undivided receipts. After all the expenses are paid the net proceeds are divided equally.

Mr. Neal keeps no record whatever of the gross income. This may seem unbusinesslike, but his policy has been to hold the tenant alone responsible for a net income sufficiently large to make the investment profitable. When an improvement on the farm is wanted the question asked the tenant is "Can you make it pay?" No restrictions as to what shall or shall not be done enter into the contract. Results are the only things demanded. The new buildings that are described later will cost more than $10,000. It will be seen that the manager has an interesting problem to solve. To increase the net proceeds nearly twofold, so as to make profits on this added investment, is a big undertaking, but neither the landlord nor the tenant is at all pessimistic about the outcome.

FARM ANIMALS.

In October, 1905, a fire destroyed all of the barns and silos, with the exception of one silo and a stable where the young stock was kept, and also destroyed the hay and feed that had been stored for the winter. This necessitated building temporary quarters for the winter of 1905–6 and the summer following; also of disposing of several cows for lack of room and fodder. The work of building new and larger barns was begun in the spring of 1906, and these are now nearing completion. But even with the adverse conditions under which the work has been done this past year, there are on this farm of 120 acres 60 cows, 43 calves and yearlings, 2 bulls, and 9 horses. Nearly all of the roughage fed these animals is grown on the place. Concentrates, such as cotton-seed meal, oil meal, and bran, are purchased. It is the purpose of the owners to increase the number of animals in the herd to 150. In 1894 they began dairy operations with 17 cows and 4 horses. The number of cows was increased to 30 in six years, and to the present number in the next seven.

Being dissatisfied with the ordinary dairy cows that were offered for sale, the owners began several years ago to raise their own stock. Each milking is weighed and an accurate record is kept of the performance of every cow. The unprofitable ones are disposed of as soon as possible. Pure-bred Guernsey bulls are used and only the heifers from the best producing cows are saved for the herd. In this way a herd has been developed whose yearly record averages nearly 7,000 pounds of milk per cow. Some of the grade Guernsey heifers at three years of age have made better records than their dams ever did. The proportion of calves and yearlings to milch cows at present on the place is unusually high. This is because of a wish to increase the size of the herd considerably in the next two years.

MANAGEMENT OF THE HERD.

The cows are put in their stalls the first of October and are not let out until warm weather in the spring. The rest of the year they are let out during part of the day in the small pasture lot to give them exercise. The young stock and dry cows are kept in separate yards from the others. These are to be stabled in the quarters now occupied by the entire herd when the milch cows are transferred to the new barn.

RATIONS.

The plan of feeding is the same in summer as in winter. The cows are fed grain in the morning before milking. After milking they get silage; alfalfa hay is fed at noon, and the grain and silage again at night. New milch cows get all they will eat of these different feeds. The quantities are gradually diminished as the period of lactation advances.

The young stock and dry cows receive more coarse fodder, such as corn stover, silage, and rye hay, and less grain than do milch cows.

Corn silage would be fed the entire year if a sufficient quantity were available. It has been found necessary at various times to substitute for it some other succulent feeds, such as beet pulp, green alfalfa, and apple pomace. The experience with apple pomace on this place indicates that not enough attention has been paid to this by-product as a feed for dairy cows. When fed in alternate periods with beet pulp the cows shrink in milk flow when on the pulp and gain when put back on the apple pomace. The pomace was stored in a long pile and covered with cornstalks. It kept fairly well under these conditions for two months. Pomace stored in casks, which is practically the same as putting it in a silo, has been known to keep perfectly for seven months.[a] In a feeding trial at the Vermont Agricultural Experiment Station, lasting two hundred and seventy days, eight cows receiving apple pomace gave the same amount of milk and 3 per cent more butter than when fed corn silage.[b] Care should be taken in getting cows accustomed to this feed. They eat it very readily and would no doubt eat too much at first if given all they wanted. Mr. Angevine gives about half a bushel to each cow twice daily.

Soiling is not practiced except when absolutely necessary. The manager considers silage in every way as good a feed as green crops, and more economical.

Bran forms the basis of the grain ration, and is often the only concentrate used. It is fed the whole year. Equal parts by weight of cotton-seed meal, oil meal, and bran were tried, and gave good results.

CROPPING SYSTEM.

There is no fixed rotation of crops practiced on this place, corn having been planted after corn on the same land in some instances for seven years. The liberal dressing of manure which the whole farm receives each year makes this possible. One field of 18 acres gave a yield of 400 bushels of shelled corn in 1894. After three years of continuous cropping with corn it gave a yield of 1,200 bushels. Meantime it had received 500 loads of manure hauled from the city. To quote the manager: "Two corn crops in succession on the same field may not sound like good farming, but the best farming I have done on this place was the growing of seven crops of corn on the same field in nine years. The first crop would not have made over 5 tons of silage per acre, and the last one made 25 tons."[a]

---

[a] Fourth Annual Report of the Hatch Experiment Station of the Massachusetts Agricultural College.

[b] Fifteenth Annual Report of the Vermont Agricultural Experiment Station.

While, as before stated, no regular plan is followed in planting the crops, a system, extremely simple in outline, that promises maximum yields of forage is gradually being developed. It is corn and alfalfa in about equal areas, with winter rye whenever it can be crowded in between two crops of corn, and oats when necessary to get a new seeding of alfalfa. Both the rye and oats are cut for hay.

Special care is taken in producing the corn that is to go into the silo. A large kind of ensilage corn is planted on well-manured and thoroughly prepared land. The field of corn that made 25 tons of silage per acre in 1905 received two coverings of stable manure—one during the early winter and the other just before plowing in the spring.

Marked success has resulted from seeding corn stubble with rye, cutting the rye for hay, and planting the same field to corn again. From a 10-acre field cropped in this manner four big loads of rye and 15 tons of silage to the acre were harvested this year.

The following table shows the acreage of crops grown during 1905 and 1906 and the plans for 1907:

System of cropping for 1905, 1906, and 1907.

Field number.	Acreage.	Crop, 1905.	Crop, 1906.	Crop, 1907.
1	17	Timothy hay	Pasture	Corn.
2	24	Pasture	Corn, sowed to rye	Rye, to be cut for hay and followed by corn.
3	32	Corn	13 acres in corn 18 acres in oats; seeded to alfalfa. 1 acre in rye; seeded to alfalfa.	13 acres in corn. 19 acres in alfalfa.
4	13	Oats, cut for hay; seeded to alfalfa.	Alfalfa	Alfalfa.
5	10	Oats, cut for grain; seeded to rye.	Rye, followed by corn; seeded to rye.	Rye, to be cut for hay and seeded to alfalfa.
6	10	Alfalfa	Alfalfa	Alfalfa.

In addition there is a pasture of 2½ acres, which is never plowed.

---

[a] In localities where fungous diseases or insect pests, such as the root aphis and the rootworm, attack the corn crop, this practice would be disastrous. As yet in the section under discussion no trouble has been experienced from these sources.

It will be seen from the foregoing table that 32 acres were in corn in 1905 and 47 acres in 1906, and that there are to be 54 acres planted to this crop in 1907.

Four years ago a 10-acre field was sown to alfalfa as an experiment. It did so well that the area devoted to this crop has been increased from 10 acres in 1905 to 23 acres in 1906, and this is to be increased to 52 acres in 1907.

Seeding alfalfa both with and after oats or rye has been successful. The plan usually followed is to disk the ground thoroughly after an oat crop has been removed and sow the alfalfa in August. The ground in 1906 was worked until it was so mellow a wheelbarrow grass seeder could not be pushed over it. Where the land has never produced alfalfa, it has been the practice to inoculate it with two or three wagonloads of pulverized sweet clover (*Melilotus alba*) sod to 10 acres. This plant grows in great abundance along the highways in this part of Michigan. On 6 acres that were seeded to alfalfa in 1906, three applications of manure, of 8 loads each per acre, were made before seeding. The field was disked after each application.

The alfalfa is cut for hay three times during the season. After the first cutting in the spring the stubble is gone over with a disk harrow. In case June grass gets started it is disked twice during the year. The stand of alfalfa on this place is as good as any the writer has ever seen.

BUILDINGS.

The buildings that escaped the fire were the dwelling house where the tenant lives, one small frame stable, and an adjoining stave silo. This stable stands about 15 rods from the other barns and will be used for housing the young stock and dry cows. The silo has a capacity of about 100 tons.

In building the new barns (fig. 1) care was taken to make them as nearly fireproof as possible. The ground plan of the barns is in the form of an L. The hay barn is 120 feet long, 38 feet wide, and 24 feet high to the eaves. The walls are of hollow reenforced concrete. Galvanized-iron shingles were used on the roof and to cover the gables. In this barn are horse stable, granary, feed room, and hay mows. The horse stable and granary are situated at one end of the barn and are separated by an 8-foot feed alley. There is also a central driveway crosswise of the barn. At the rear of this main barn are two circular, solid-walled, reenforced-concrete silos. These are 20 feet in diameter and 41 feet high. The silos are about 8 feet apart. Extending back from the silos and at right angles to the longer dimension of the hay barn is the cow stable (fig. 2). This is 38 feet wide and 154 feet long. The inside height is 8 feet 4 inches in the clear. There is no wood in this stable except that used in making the stalls and feed boxes. The walls, floor, roof, crossbeams, and even the pillars that support the roof are made of reenforced concrete. Fifty-seven windows in the walls, each 24 by 40 inches in size, and three skylights in the roof furnish plenty of light. The King system of ventilation was installed. The double walls made this an easy matter. For the intake of fresh air, flues about 4 by 8 inches are partitioned off in the walls about every 10 feet, and extend from the bottom to the top of the wall. The outside opening to this flue is about a foot above the ground. The inside opening is near the ceiling. To remove the foul air two circular chimneys, with an inside diameter of 3 feet 4 inches and a height of 50 feet, were built, one near each end of the stable. These were placed at one side of the central feeding alley. The walls of these chimneys are solid reenforced concrete, being 6 inches thick for the first 10 feet and for the remainder 4½ inches. Six 10 by 12 inch openings are left at the bottom of the wall of each stack for the intake of air and heavy gases.

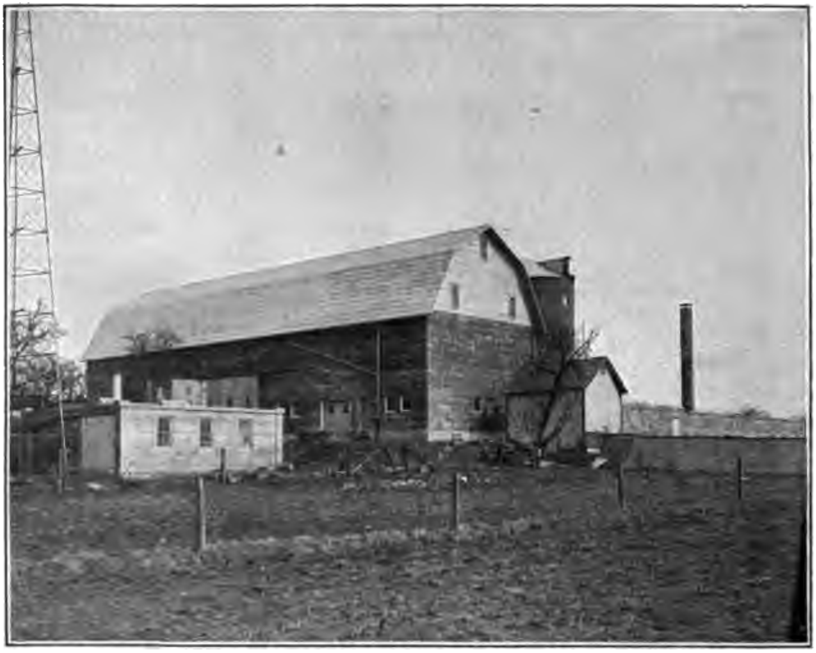


FIG. 1.—Concrete barns on the farm of J. N. Neal.

Two rows of stalls facing a central feeding alley extend the whole length of the stable. The essential feature of the kind of stall used is the movable front, which can be adjusted according to the length of the cow. With this device and a gutter behind them the cows can be compelled to keep clean. An individual drinking trough is in every stall. The ceiling of the cow stable is fitted with tracks for litter and feed carriers. The roof is carried through between the two silos, forming a covered passageway which connects the feeding alley of the cow stable with the alley of the hay barn.

About 45 feet in front of the main barn and at one side of the driveway is the milk house. This building is 20 by 26 feet, one story in height, with a receiving tower at the corner nearest the barn. The ground between the storage barn and the milk house descends quite rapidly, so that the roof of the milk house—which is the floor of the receiving tower—is on a level with the floor of the barn. This intervening space has been filled in with dirt. As soon as it is drawn, the milk is poured into 10-gallon cans and wheeled to the front door of the barn. The can is then suspended from a car on a taut wire cable, which extends from the barn to the milk house, and is run to the receiving tower. The milk is poured through a strainer in the floor of the tower on to the aerator. The milkers do not have to enter the cooling room at all. Reenforced concrete is used exclusively in the construction of the walls, floor, tanks, roof, and chimney of this building. The walls are hollow, like those of the barn.

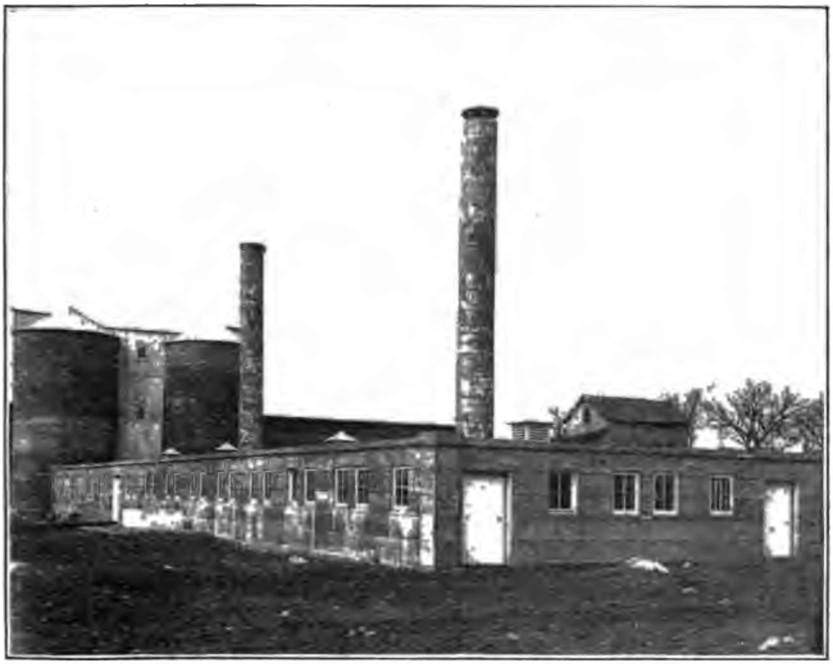


FIG. 2.—The cow stable, showing ventilating chimneys, with the silos in the distance.

HIRED HELP.

Five men are employed the year round. These men have been on the place from two to seven years. Four of them milk from 10 to 15 cows each. Two of the milkers drive the delivery wagons on the city milk route and take care of the cans and milking utensils. One attends to feeding the stock and to the chores about the barns. The fourth while not milking is engaged at labor in the fields. One man devotes his entire time to general work in the fields. A few day hands are hired during busy times, such as the haying and silo-filling seasons.

HOURS OF WORK.

The milking takes about two hours twice a day. It is the first work done in the morning, commencing at 4.30, and is finished in the evening at 6 o'clock. It takes the two men who drive the milk wagons about five hours to deliver the milk and one hour to take care of the wagons and cans. The farm men work about nine hours in the field.

WAGES.

The two men who drive the milk wagons receive $25 a month. The barn man gets $6 a week. One farm hand is paid $23 a month; the other, a boy, $18 a month. The wages paid the temporary help vary from 50 cents a day for boys to $2.50 a day for skilled men. All of the laborers are furnished board.

HANDLING MANURE.

Sawdust is used for bedding in the stalls and as an absorbent. This renders the manure especially adaptable for disking in, as in the case of fitting oat stubble for alfalfa. No ill effects on the soil have ever been noticed from the use of this material.

A litter carrier, suspended from an overhead track, carries the manure from the stable and dumps it on a manure spreader. The spreader (fig. 3) stands on a rectangular cement foundation, built with sides about 2 feet above the floor. The ends of the floor are raised so that any drippings from the spreader can not escape, but not high enough to prevent driving the spreader on or off. By keeping some absorbent litter, which is changed when necessary, on this foundation all the liquid, as well as the solid manure, is saved without recourse to a manure cistern. A roof over this foundation, supported by 7-foot posts, keeps off rain and snow. The manure is hauled to the fields daily. Experience has shown that it injures the texture of the soil very much to drive a loaded wagon over it when it is too wet. To avoid this trouble, the building in the near future of a shed large enough to store the manure accumulating during the wet periods of the year is contemplated. In the past it has been the custom to haul from 400 to 500 loads of manure a year from the city, but this is not practiced any more, enough being produced by the herd to cover the whole farm with 6 to 8 tons to the acre each year. Commercial fertilizers have been tried in small quantities, but their use has been abandoned.

EQUIPMENT.

The implements and machinery in use on this farm are three wagons, two disk harrows, one smoothing harrow, two walking plows, one gang disk plow, two 2-horse cultivators, one corn binder, one mowing machine, one 2-row cultivator, one manure spreader, one weeder, one combined fertilizer and grain drill, one 15-horsepower gasoline engine, and one silage cutter. "One of the best tools is a float made of three 8-foot poles, weighted so as to make a good load for three heavy horses."

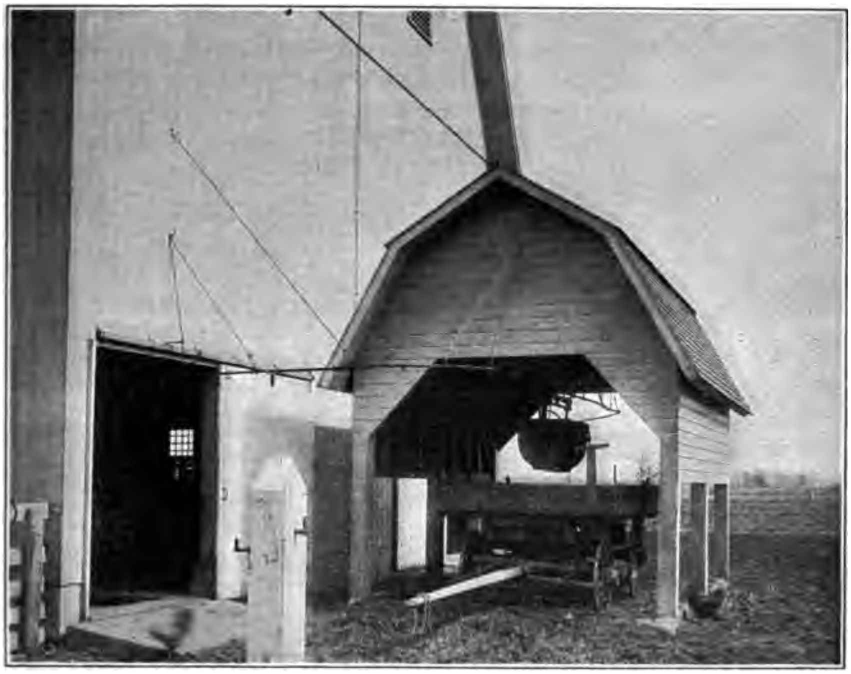


FIG. 3.—The shed where the manure spreader stands.

DISPOSAL OF PRODUCT.

Most of the milk from the dairy is retailed in a near-by city. Two delivery wagons are used. There are several first-class dairies supplying this same market, and the competition is very keen. The financial success of this farm can not therefore be attributed to high prices received for the milk. The usual rate is 5 cents a quart for whole milk delivered to the consumer.

FINANCIAL STATEMENT FOR 1905.

It is impossible to give an exact itemized statement of expenses or of returns. Hence the following table contains only round numbers. These, however, are believed to be substantially correct.

The figures are for the year 1905. During that year the herd contained 45 cows. About one-third of the milk was sold at wholesale at 4 cents a quart and the remainder at retail at 5 cents. Some days there was a surplus, and there were occasional losses from accident. The principal loss, however, resulted from the failure of drivers to keep accurate records of all milk sold on account. Mr. Angevine thinks the losses from this source alone were more than $1,000. He now uses a ticket system, which prevents most of this loss.

Receipts and expenditures, 1905.

Receipts for milk retailed		$5,500
Miscellaneous receipts for hogs, calves, chickens, etc		500
Total receipts		6,000
Paid out for feed	$1,000	
Labor, five regular hands	1,404	
Labor (day help) and other expenses	596	
Total expenses		3,000
Net proceeds		3,000

O

976 Issued A

U. S. DEPARTMENT OF AGRICULTUR

FARMERS' BULLETIN 281.

Experiment Station W

XL.

Compiled from the Publications of the Agricultural Experiment Statio

---

INSOLUBLE PHOSPHATES.
FORMS AND METHODS OF APPLYING LIME.
SEDIMENT IN IRRIGATION WATER.
HARDY BERMUDA GRASS.
WILLIAMSON METHOD OF CORN CULTURE.
KILLING SASSAFRAS SPROUTS.
SOLUBLE OILS FOR SAN JOSÉ
CORN AS FOOD FOR MAN.
STORING PRESERVES AND CA
INCUBATION OF CHICKENS.
PREVENTION OF NODULE
LAMBS.
SOME MILK TERMS.

MARCH, 1907.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.
A. C. TRUE, Director.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

THE AGRICULTURAL EXPERIMENT STATIONS.

- ALABAMA—
  - College Station: *Auburn;* J. F. Duggar.[a]
  - Canebrake Station: *Uniontown;* J. M. Richeson.[b]
  - Tuskegee Station: *Tuskegee;* G. W. Carver.[a]
- ALASKA—*Sitka:* C. C. Georgeson.[c]
- ARIZONA—*Tucson:* R. H. Forbes.[a]
- ARKANSAS—*Fayetteville:* W. G. Vincenheller.[a]
- CALIFORNIA—*Berkeley:* E. J. Wickson.[d]
- COLORADO—*Fort Collins:* L. G. Carpenter.[a]
- CONNECTICUT—
  - State Station: *New Haven;* E. H. Jenkins.[a]
  - Storrs Station: *Storrs;* L. A. Clinton.[a]
- DELAWARE—*Newark:* Harry Hayward.[a]
- FLORIDA—*Gainesville:* P. H. Rolfs.[a]
- GEORGIA—*Experiment:* Martin V. Calvin.[a]
- HAWAII—
  - Federal Station: *Honolulu;* J.G.Smith.[c]
  - Sugar Planters' Station: *Honolulu;* C. F. Eckart.[a]
- IDAHO—*Moscow:* H. T. French.[a]
- ILLINOIS—*Urbana:* E. Davenport.[a]
- INDIANA—*Lafayette:* A. Goss.[a]
- IOWA—*Ames:* C. F. Curtiss.[a]
- KANSAS—*Manhattan:* C. W. Burkett.[a]
- KENTUCKY—*Lexington:* M. A. Scovell.[a]
- LOUISIANA—
  - State Station: *Baton Rouge.*
  - Sugar Station: *Audubon Park, New Orleans.*
  - North Louisiana Station: *Calhoun;* W. R. Dodson (*Baton Rouge*).[a]
- MAINE—*Orono:* C. D. Woods.[a]
- MARYLAND—*College Park:* H. J. Patterson.[a]
- MASSACHUSETTS—*Amherst:* W. P. Brooks.[a]
- MICHIGAN — *Agricultural College:* C. D. Smith.[a]
- MINNESOTA—*St. Anthony Park, St. Paul:* W. M. Liggett.[a]
- MISSISSIPPI—*Agricultural College:* W. L. Hutchinson.[a]
- MISSOURI—
  - College Station: *Columbia;* H. J. Waters.[a]
  - Fruit Station: *Mountain Grove;* P. Evans.[a]
- MONTANA—*Bozeman:* F. B. Linfield.[a]
- NEBRASKA—*Lincoln:* E. A. Burnett.[a]
- NEVADA—*Reno:* J. E. Stubbs.[a]
- NEW HAMPSHIRE—*Durham:* W. D. Gibbs.[a]
- NEW JERSEY—*New Brunswick:* E. B. Voorhees.[a]
- NEW MEXICO—*Agricultural College:* L. Foster.[a]
- NEW YORK—
  - State Station: *Geneva;* W. H. Jordan.[a]
  - Cornell Station: *Ithaca;* L. H. Bailey.[a]
- NORTH CAROLINA—*Raleigh:* B. W. Kilgore.[a]
- NORTH DAKOTA—*Agricultural College:* J. H. Worst.[a]
- OHIO—*Wooster:* C. E. Thorne.[a]
- OKLAHOMA—*Stillwater:* W. L. English.[a]
- OREGON—*Corvallis:* J. Withycombe.[a]
- PENNSYLVANIA — *State College:* H. P. Armsby.[a]
- PORTO RICO—*Mayaguez:* D. W. May.[c]
- RHODE ISLAND—*Kingston:* H. J. Wheeler.[a]
- SOUTH CAROLINA—*Clemson College:* J. N. Harper.[a]
- SOUTH DAKOTA—*Brookings:* J.W.Wilson.[a]
- TENNESSEE—*Knoxville:* H. A. Morgan.[a]
- TEXAS—*College Station:* J. W. Carson.[d]
- UTAH—*Logan:* P. A. Yoder.[a]
- VERMONT—*Burlington:* J. L. Hills.[a]
- VIRGINIA—*Blacksburg:* A. M. Soule.[a]
- WASHINGTON—*Pullman:* E. A. Bryan.[a]
- WEST VIRGINIA—*Morgantown:* J. H. Stewart.[a]
- WISCONSIN—*Madison:* W. A. Henry.[a]
- WYOMING—*Laramie:* B. C. Buffum.[a]

---

[a] Director. [b] Assistant director. [c] Special agent in charge. [d] Acting director.

EXPERIMENT STATION WORK.

Edited by W. H. BEAL and the Staff of the Experiment Station Record.

Experiment Station Work is a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce " rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. TRUE, Director, Office of Experiment Stations.

CONTENTS OF NO. XL.

Page.

Insoluble phosphates 5

Forms and methods of applying lime 7

Fertilizing value of sediments in irrigation water 8

Hardy Bermuda grass 10

The Williamson method of corn culture 13

Carbon bisulphid for killing sassafras sprouts 16

Soluble oils for the control of San José scale 17

Indian corn as food for man 18

Storing preserves, canned fruits, and canned vegetables 22

Natural and artificial incubation of chickens 24

Bare-lot method of raising lambs to avoid nodule disease 28

Some milk terms 29

EXPERIMENT STATION WORK.[a]

INSOLUBLE PHOSPHATES.[b]

The fertilizing value of fine-ground insoluble phosphates (floats) is attracting considerable attention at the present time. The work of C. E. Thorne, of the Ohio Station; C. G. Hopkins, of the Illinois Station, and H. J. Patterson, of the Maryland Station, especially, has encouraged the hope that under certain conditions the cheaper untreated phosphates may be used with profit, as explained in a previous bulletin of this series.[c] Experiments under other conditions, however, suggest caution in the general application of the results obtained in the above experiments.

For example, experiments made by W. P. Brooks at the Massachusetts Experiment Station have emphasized the fact established by the earlier experiments at the Maine Station that the kind of crop to be grown will often determine whether it is profitable to use the insoluble phosphates.

H. J. Wheeler and G. E. Adams, of the Rhode Island Station, have recently reported experiments extending over a series of years in which floats were compared with a number of other soluble and insoluble phosphates on corn, grass, and a great variety of other crops on limed and unlimed soil, showing a wide variation in the efficiency of the insoluble phosphate under varying conditions of soil, crop, etc.

The floats gave very poor results on corn the first year as compared with the other phosphates. In subsequent years, however, the phosphoric acid of the floats slowly became available and gave good results on both corn and grass. It is probable that in the case of the grass the accumulating organic matter materially aided in rendering the phosphoric acid of the floats assimilable.

In view of the low price of floats and the relatively large amount of phosphoric acid applied in consequence, these results demonstrate that if one begins upon land deficient in assimilable phosphoric acid, even with Indian corn, one should not place too much reliance upon the floats the first year, but should supplement them with some soluble phosphate. In later years they appear to be of marked value in connection with timothy, and especially with redtop and Indian corn.

---

[a] A progress record of experimental inquiries, published without assumption of responsibility by the Department for the correctness of the facts and conclusions reported by the stations.

[b] Compiled from Rhode Island Sta. Bul. 114.

[c] U. S. Dept. Agr., Farmers' Bul. 262, p. 7.

In case of peas on limed soil floats gave very good results, confirming the general conclusion " that the legumes have, as a rule, a marked ability to acquire phosphoric acid from certain unacidulated mineral phosphates." With " oats, summer squash, crimson clover, Japanese millet (on the unlimed land), golden millet, white-podded Adzuki bean, soy bean, and potato (on the unlimed land) floats [also] gave very good results, but with the flat turnip, table beet, and cabbage they were relatively very inefficient, notwithstanding that much more phosphoric acid had been applied in the floats than in any other of the phosphates."

The results in general indicate that—

> Floats can probably be used to best advantage on moist soil rich in decaying vegetable matter, and for such crops as certain legumes, Indian corn, millet, and possibly wheat and oats, which seem far better able to make use of them than certain vegetables. The vegetable growers in the East should not be influenced to use them on account of their reported value on the Illinois black soil of the corn belt, where wheat, grass, clover, and Indian corn are the chief crops, and where the soil conditions are exceptionally favorable to their ready assimilability. Perhaps it may be found that floats can be advantageously mixed with the stable manure which gardeners collect during the winter, but this is a point which needs to be more definitely determined. The fact that phosphoric acid in floats costs less than half what it does in bone makes it most desirable to utilize the former where it can be done to advantage, but the Rhode Island gardener and general farmer will do well to study the foregoing results carefully before employing the floats extensively or depending upon them at the outset, or his bank account may pay the penalty.

The conditions under which these experiments were made in Rhode Island are to a considerable extent representative of those of other parts of the eastern United States where diversified and intensive farming is largely practiced on thin, worn soils. It seems quite clear from the results of all the experiments which have been made under such conditions that (1) the insoluble phosphates are not equally effective on all crops, and hence are not generally well adapted to intensely diversified farming, such as market gardening; (2) they are slower in action than soluble phosphates, and hence not well suited to short-season, quick-growing crops; (3) they do not, as a rule, prove very efficient on thin, worn soils deficient in decaying organic matter, and hence if they are to give good results on such soils they must be used in connection with liberal applications of barnyard manure and green manures.

FORMS AND METHODS OF APPLYING LIME.[a]

H. J. Patterson, of the Maryland Experiment Station, has recently reported the results of fourteen years' experiments on the relative value of different kinds of caustic, quick, or burnt lime (fat or rich stone lime, poor magnesian stone lime, oyster-shell lime), slaked lime, gas-house or gas lime, gypsum or land plaster, ground limestone, marl, and phosphate of lime, as well as soft-coal ashes, when applied in different ways (slaked and unslaked, as top-dressing, or worked into the soil) and amounts in a common crop rotation (corn, wheat, and timothy and clover), in connection with green manures (cowpeas) and with stable manure.

It was found that in case of the rotation named, on a run-down sandy loam, naturally well drained, limed plats gave larger yields than unlimed plats, the average net return from liming being $4.50 per acre annually, valuing corn at 40 cents per bushel, corn fodder at 20 cents per hundredweight, wheat at 90 cents per bushel, straw at 20 cents per hundredweight, and hay at 50 cents per hundredweight. A net return of $4.50 per acre means a profit of $450 to $600 annually when applied to a 100-acre or a 150-acre farm, respectively.

A study of the most profitable rate of applying lime showed that an application of 20 bushels per acre gave only about 25 per cent more net profit than an application of 10 bushels, and of 60 bushels only about 50 per cent more than 10 bushels, but that the relative profits at the end of four years were in favor of 20 bushels per acre. On unproductive, stiff, rather wet clay soil it was found to be decidedly advantageous to use lime at the rate of 40 bushels per acre in combination with a green manuring of cowpeas. It was also found to be advantageous on the same kind of soil to use lime in combination with stable manure. "The net profits per year from the use of 12 tons of manure and 20 bushels of lime per acre are greater than have been obtained in any of the other lime tests and are in a measure an explanation for the better crops which are obtained in those sections of the State that have used lime and manure extensively for generations."

In these experiments the results slightly favored the incorporation of unslaked lime with the soil immediately upon application rather than applying it as a top-dressing.

Oyster-shell lime was apparently somewhat more effective than stone lime, though the difference was not marked. Magnesian lime produced decidedly better yields of grain than pure lime, though not quite so much forage. Calcium carbonate (2,600 pounds per acre) gave decidedly better results than caustic lime, and the application of shell marl (13,000 pounds per acre) produced more grain and forage than either stone lime or oyster-shell lime. Caustic lime and fine-ground oyster shells (calcium carbonate) were cheaper and much more effective than gypsum or land plaster (4,125 pounds per acre). Caustic lime was also much more effective than gas lime (2,925 pounds per acre) of oyster-shell origin. Calcium phosphate in the form of finely ground South Carolina rock (2,925 pounds per acre) gave better results than gypsum, but not so good as either calcium carbonate or caustic lime. Soft-coal ashes (13,000 pounds per acre) produced little if any effect.

---

[a] Compiled from Maryland Sta. Bul. 110. See also U. S. Dept. Agr., Farmers' Buls. 65, 77, 122, 124, 133, 237, 259.

FERTILIZING VALUE OF THE SEDIMENT IN IRRIGATION WATER.[a]

The rivers of arid regions generally carry large amounts of sediments, particularly in times of flood. The Nile, which by its annual overflows has maintained the marvelous fertility of Egypt through untold ages, is a well-known but typical illustration of the importance of water sediments in relation to the maintenance of soil fertility. Similar illustrations may be cited in case of other streams, either in connection with natural floods or with the use of their waters in irrigation.

The Office of Experiment Stations of this Department, through its Irrigation and Drainage Investigations, has determined the amount of silt or sediment carried by various streams used for irrigation. These determinations show, for example, that the principal Texas streams—the Rio Grande and the Brazos and Colorado rivers—carry from about 0.65 to nearly 3 per cent of sediment, it being calculated from the measurements which have been made that the Brazos, for example, carries enough sediment during the year to cover 40,000 acres 1 foot deep.

R. H. Forbes, of the Arizona Station, has made a very careful study of the sediments carried by the Gila, Salt, and Colorado rivers in Arizona. He estimates that the Gila River at Florence carries on an average 19.23 tons of sediment per acre-foot of water, the Salt River at McDowell 1.2 tons, the Colorado River at Yuma 9.62 tons. The amounts, however, vary very widely at different times. The average amounts stated would furnish on the average 214 pounds of potash per acre annually, 37 pounds of phosphoric acid, and 28 pounds of nitrogen in case of the Gila River; 18 pounds of potash, 6.6 pounds of phosphoric acid, and 5.5 pounds of nitrogen in case of Salt River, and 113 pounds of potash, 10 pounds of phosphoric acid, and 4.8 pounds of nitrogen in case of the Colorado River. Analyses by G. E. Colby, of the California Station, of samples of creek waters used for irrigation in the Santa Clara Valley, California, as reported by S. Fortier, of the Irrigation and Drainage Investigations of the Office of Experiment Stations, showed, however, that a 12-inch irrigation with these waters added only 4.55 pounds of available potash and 1.3 pounds of phosphoric acid to each acre of land.

---

[a] Compiled from Arizona Sta. Buls. 44, 53; U. S. Dept. Agr., Office of Experiment Stas. Buls. 133, p. 200; 158, p. 85.

These facts merely serve to give definite form to the knowledge, as old as human history, that river irrigating sediments increase the productiveness of land. The varying values, shown in our southwestern river sediments, call to mind the parallel fact, known in Egypt since ancient times, that the Red Nile floods from Abyssinia are more valuable than those from other watersheds tributary to that river.

The calculations, however, are based upon the assumption that all of the sediment reaches the irrigated fields, but—

By no means all of the sediments are carried upon irrigated fields. With gentler gradients and slackening motion of the water, the heavier portions are soon dropped in canals and laterals, necessitating the never-ending work of ditch cleaning. The remaining lighter portions are carried upon irrigated ground where, with still further decrease in the movement of the water, the residual solids are deposited in large part near the point of diversion from the supply ditch.

In considering the effects of sediments upon lands, therefore, it is necessary to allow for the manner in which they are distributed, this distribution being affected by the kind of crop, the method of irrigation, and the slope, as well as by the fineness of the sediments themselves.

While we calculate, therefore, that 4 average acre-feet of Colorado River water at Yuma carry sediment enough to make a layer of soil about one-fourth of an inch thick each year, the larger portion of this amount is actually concentrated upon probably much less than half of the ground irrigated.

Rising ditch banks and increasing gradients in irrigated fields under muddy streams attest the activity of this factor and suggest that in this region in time to come the disposal of ditch cleanings and field deposits may become a serious problem.

While the fertilizing value of these sediments is undoubted, the results of their accumulation on irrigated soils are often decidedly injurious.

Irrigating sediments may be beneficial or harmful to crops according to their composition and physical character and their disposition in or upon the soil. Whether beneficial or harmful in composition, if they accumulate upon the surface of the soil in the form of silt blankets more or less impervious to water and air, their influence, by limiting the supply of these essential substances to plant roots, is notably harmful. In certain localities where these irrigating sediments are very plastic in character and excessive in amount the damage, particularly to alfalfa and other crops which can not receive constant and thorough cultivation, is of an increasingly serious character.

Cultivation, where practicable, as deep and thorough as possible is the best available means of handling these accumulations. Beneficial sediments are thus incorporated with the soil and their fertilizing properties made available to plant roots, while sediments of barren character are dispersed to the depth of cultivation through the soil. When, however, sediments of undesirable character predominate cultivation can only modify and not remedy resulting conditions.

In such cases it is desirable to lessen the sediments in irrigation waters by means of settling basins and similar devices.

HARDY BERMUDA GRASS.[a]

In recently settled prairie regions the problem of grass culture does not usually present itself until the wild lands are largely brought under cultivation and the individual farms are becoming well stocked with farm animals. Up to this time the wild grasses have furnished sufficient hay and pasturage and, as a rule, little thought has been given to providing forage from another source. Under these conditions the problem is rather difficult of solution, for the settler finds himself in a new environment, soil and climate probably differ largely from these same factors in the region from which he came, and no advice founded on actual experience is available by which he might be guided in laying down cultivated land to grass. In Oklahoma where these conditions obtain, the experiment station realized that sooner or later this question would have to be met, and therefore has come to the assistance of the farmer through data gathered in grass culture tests begun in 1892. This work, which is still in progress, has now been followed for fourteen years, and the recommendations based on the results secured, which the institution at the present time is able to make, are of special value to the region concerned.

The results of these tests, as well as of cooperative work with farmers over the Territory, indicate that of all the grasses coming under observation Bermuda grass alone has shown the necessary qualities of a pasture grass for Oklahoma. One of the first experiences with this grass grown from seed was that although it made a good growth during the season, it killed back during the winter and made a late start in the spring. With these disadvantages the species failed to fulfill two very essential conditions of a successful pasture and lawn grass, but through the efforts of the station these objections have been largely overcome. On several test plats plants were observed which showed a superior resistance to cold weather, combined with an early spring growth, beginning to grow as early as April 1 even after a severe winter. This observation suggested a line of work for the improvement of Bermuda grass and its culture. A large planting of roots was made in July of 1904. Part of these roots were taken from a plat recently grown from seed and part from plats that had been established at least ten years and had passed through a cold period with a minimum temperature of 17° below zero and with no snow on the ground. This planting made an almost uniform heavy growth before frost. The following spring, after a winter with temperature records of 18° below zero, the plants grown from the acclimated roots produced on the long-established plats were found growing vigorously on March 29, and these soon covered the ground and kept out the crab grass, while the plats planted with roots recently grown from seed had all of their previous season's growth killed back. Some of the plants were entirely killed out and all that survived did not begin to grow again until May and were almost overwhelmed by crab grass.

---

[a] Compiled from Oklahoma Sta. Bul. 70.

A further test was made of the hardy strain by sending the roots for trial to every county in the Territory. The reports from these cooperative trials indicate in general that this hardy grass was much more vigorous than that grown from seed, that the stems remained green throughout the winter, and that it began its new growth in March. One of the experimenters, who had tried growing Bermuda grass from seed many times only to have it frozen out every winter, reported that with him this hardy strain began its growth about March 5, and that he regarded it as an entirely satisfactory pasture grass if not pastured until the second year, and then not too closely, in order to allow the runners to become firmly rooted.

A number of tests of this hardy Bermuda grass for lawn purposes were also made with satisfactory results. The principal objection to this species, even if a hardy strain has been secured, is that it does not remain green during winter. The station has also found a means of mitigating this disadvantage to a large extent. "A covering of Bermuda grass on the lawn will not hinder the germination of white clover or Kentucky blue grass seed sown into it in September. Some of the white clover will persist and show up early in the spring. There are areas on the college campus here where white clover and Bermuda grass have been growing together for five years. From February to May the white clover makes excellent growth and the Bermuda is scarcely noticeable. From June to October the Bermuda grass covers the ground with a mat of green and the clover almost disappears. This combination of white clover and Bermuda grass promises well, and may ultimately be useful for pastures as well as lawns. But the foundation should be a perfect sod of hardy Bermuda grass."

To effect a rapid distribution of Bermuda grass the station advises the planting of sod from grass which has successfully survived several winters and starts its new growth by April 1 of each year. Seed of hardy Bermuda grass for Oklahoma is not obtainable, but the expense of starting the grass from a home-grown supply of sod is not so great as starting it from seed.

As a soil preparation for planting the sod, winter plowing and frequent harrowings are recommended. The planting may be done from April 15 to July 15, the sod being placed in furrows made with a single shovel plow about 6 inches deep and 3 feet apart. The pieces of sod from 1 to 2 inches square are dropped 18 inches apart in the newly made furrows and covered with either the foot hoe or double-shovel plow, a thicker covering being given when the soil is dry than when it is wet in order to assure the necessary moisture conditions. Harrowing does not sufficiently cover the sod. When roots free from dirt are planted the soil is prepared in the same way, but the roots are set out more carefully than the sod, the soil being firmed about them and a little of the root left exposed to the air, while the sod is completely covered. The new plantings of Bermuda grass are cultivated the same as corn or potatoes to kill out the crab grass and other weeds and to promote the rooting of the grass by providing loose soil, but as soon as the runners begin to extend from one row to another and there is danger of tearing them away cultivation is discontinued. Worn-out pastures, loose sandy soils, and waste land with a scanty growth of timber and poor grass may all be transformed into useful pastures by planting sod as described and allowing the grass to establish itself during the first season. At the station thin, well-cultivated upland soil was set out to Bermuda grass by planting small pieces of sod 18 inches apart in rows 3 feet apart on June 29 and 30, 1905, and the grass cut from this planting September 25, 1905, was entirely free from weeds and crab grass and yielded 2,584 pounds of cured hay per acre. The rainfall during the three months in which this crop was grown was 14.18 inches, as compared with 9.62 for the same period in previous years. An analysis of the hay showed that it contained 9.20 per cent of protein and 1.24 per cent of fat, as compared with 5.9 per cent of protein and 2.5 per cent of fat for timothy hay, 7.8 per cent protein and 3.9 per cent fat for Kentucky blue grass hay, and 14.3 per cent of protein and 2.2 per cent of fat for alfalfa hay.

Although hardy Bermuda grass is not easily killed out, it is not believed that at this latitude it will spread and become a pest in fields and other places where it is not desired. " Its place is for permanent pasture, for hay on good land subject to overflow, and for a solid covering of the lawn and the usual muddy spots about house and feed lots." At the station it is giving a profitable yield of pasture on land so full of white alkali that no other crop will grow. It has also been found most effective in sodding ditches in cultivated fields, pond banks, and other bare places, to prevent washing.

THE WILLIAMSON METHOD OF CORN CULTURE.[a]

Considerable interest and discussion have been aroused during the past two years among corn growers in the South by the exploitation of the so-called Williamson method of corn culture. This is largely due to the fact that the method involves a new principle and one departing widely from generally accepted ideas on corn growing. If the method is successful in achieving the object sought, it is of the greatest importance to that section of the country for which it is intended. An undesirable feature in the growth of corn in the South is the tendency to produce a large stalk at the expense of the yield of grain, and the primary object of this new method of culture is to produce more grain and less stalk. In a recent bulletin the South Carolina Experiment Station presents a detailed description of the method as authorized by Mr. E. M. Williamson, the originator, and also reports the results of observations made on farms where corn is grown according to this plan.

It appears that of the fields inspected all were planted with corn secured from Mr. Williamson except two, one of which was planted with a variety similar to the Williamson corn and the other with Marlboro Prolific. The Williamson corn bore the ears about 3 feet and the Marlboro Prolific about 26 inches above the ground. The number of ears per stalk or the size of the ears of the Marlboro Prolific was apparently not influenced by the method of culture. " The Williamson corn habitually bears one ear to the stalk, and the ears, when grown by the Williamson plan, are from 6 to 8 inches long and from 7½ to 10 inches in circumference. The type is intermediate between southern gourd seed and the standard dent. The grains are (white) from eight to eleven sixteenths of an inch long, four to six sixteenths of an inch wide, and two or three sixteenths of an inch thick. The cob is usually red and from 4½ to 5½ inches in circumference, the circumference measurements being taken one-third the cob length from the butt. A hundred pounds of ears shell from 82 to 90 pounds of grain. Eighty-five to 100 ears will shell a bushel of corn."

Mr. Williamson advocates plowing the land during the winter about one-fourth deeper than it was plowed before if the soil has never been broken deep enough for corn, or one-third deeper if much vegetable matter is to be turned under. Subsoiling to a greater depth may be practiced in connection with plowing at any time, provided no more subsoil than is turned up by the plow is worked to the surface. The disk plow is very effective in turning under cotton or cornstalks without previous chopping, and it also works well in pea vines. The next step is bedding the land in 6-foot rows with the turn plow, and in doing this a 5-inch balk is left, which is broken out with the scooter just before planting. The scooter furrow is deepened with the Dixie plow with the wing taken off, and a ridge is then thrown on this furrow with the same plow. As soon as the danger of frost is over the corn is planted on this ridge at the rate of one kernel every 5 or 6 inches. Early planting is especially necessary on very rich lands to prevent stalks from growing too large. The first working is given soon after planting with the harrow or any suitable implement that will not cover the plants. The crop is worked the second time when the plants are about 8 inches high, a 10 or 12 inch sweep being used on both sides of the row. After this the corn is thinned to about 16 inches in the drill. Up to this time the system of culture has been quite regular, but here the distinctive feature of retarding the stalk is introduced. The crop is not cultivated again until the stalks have been so retarded and hardened that they will not grow too large. The richer the land the greater the thoroughness required in the retarding process. Experience and judgment are necessary to decide when the corn has been sufficiently held back and the work of assisting the plant in developing the ear should begin. At this period the corn is from 12 to 18 inches high. The first fertilizer application is now made by putting half of the mixed fertilizer, consisting of 200 pounds of cotton-seed meal, 200 pounds of acid phosphate, and 400 pounds of kainit per acre, in the old sweep furrow on both sides of alternate middles and covering the same by breaking out this middle with the turn plow. About a week later the other middles are treated in the same way. After a few days the corn is sided in the first middles with a 16-inch sweep and nitrate of soda put in this furrow and covered with one furrow of the turn plow. Peas are then sown broadcast at the rate of at least 1 bushel per acre in this middle and the work finished by breaking out. Several days later the other middles are given exactly the same treatment. If the application of nitrate of soda exceeds 150 pounds per acre, one-half the quantity is applied in the first and the other half in the second middles, otherwise the entire application is made in the first middles. In Darlington County, S. C., where Mr. Williamson is practicing this method, this final application of nitrate of soda is made during an average season from June 10 to 20, and the last plowing is also done at this time.

---

[a] Compiled from South Carolina Sta. Bul. 124; Alabama Sta. Bul. 138.

The peculiar or essential features of the Williamson method are summarized as follows: Deep and thorough preparation of seed bed, deep planting, infrequent and partial cultivation in the early stages of growth, an increase of 200 per cent or more in the number of stalks per acre, postponing the application of fertilizers until the corn is given its second cultivation, intentional retardation of the early growth of the stalk until its size is reduced one-half or one-fourth of

its normal development, and following this an augmented d
ment of the yield by cultivation and heavy applications of fer
made at appropriate intervals. It is believed that since the
planted 4 to 6 inches below the level and is laid by 4 to 6 inche
the level, the brace roots, being below the surface, are probabl
able to perform their nutritive functions than if a part of the
exposed to the air. The application of fertilizers given above
ommended for a 50-bushel crop, and it is suggested that for a
100 bushels per acre the quantities should be doubled.

The Alabama Station made a comparison of the Williams
the ordinary methods of corn culture in 1906, and the bulletin
ing the results enumerates the distinctive features of the Will
method as follows: Dwarfing the corn plant by withholdin
tilizers until the plant is several feet high and by omitting all c
tion from the time the plant is about 8 inches high until it i
18 inches high, thick planting in the row, the use of the turn
the last cultivations, and planting on land enriched by plowing
the entire growth of cowpeas. The comparative test was m
two plats of poor gray sandy upland soil prepared and fe
alike. On both plats a fair growth of velvet beans was plowed
in February. The rows were laid off 6 feet apart and bedd
the water furrows thus formed being subsoiled with the Dix
plow with wing removed. A slight list was then formed in th
furrow with the same plow. This list was opened and th
planted on April 19, not as early as recommended by Mr. Willi
An application of 200 pounds of cotton-seed meal, 200 pounds
phosphate, and 400 pounds of kainit per acre was made June
a further application of 200 pounds of nitrate of soda in side f
was made July 7, when the crop was cultivated with scoot
scrape and cowpeas were sown and plowed in.

The details of cultivation on the two plats were identical
in the later hoeing, thicker planting, omission of two early c
tions, and the use of the turn plow in laying by on the Will
plat. After planting the middles were cultivated shallow o
plats. Nothing further was done on the Williamson plat unti
21, when it was hoed and thinned to one plant every 16 inches.
ing this time the check plat was given two cultivator trips p
May 21, a hoeing and thinning to one plant every 33 inches
and cultivation with scooter and scrape, five furrows per row,
The cultivation of the middles was finished June 23 with th
turn plow on the Williamson plat and with scooter and scrape
check plat.

The thicker planting and the omission of cultivation betw
early part of May and June 23 dwarfed the plants on the Will

plat. The yield of shelled corn on the Williamson plat was 30.5 bushels per acre and on the check plat 29.5 bushels. On the Williamson plat each plant averaged 0.346 of a pound of shelled corn and on the check plat 0.667 of a pound. The average weight of shucked ear or nubbin on the check plat was 0.54 of a pound as compared with 0.45 of a pound on the Williamson plat. The average height from the ground to the joint from which the lower ear grew was 44½ inches on the check plat and 36¼ inches on the Williamson plat. The ordinary method of culture showed 14 per cent of broken-over plants and the Williamson method 29 per cent.

At no time during the growing season did either plat suffer for moisture. The cost of 1,000 pounds of commercial fertilizer was $12.80 and the value of the crop at 70 cents per bushel $21.35. These results were not profitable, and the results of other experiments made by the station in various localities of the State lead to the belief that the proportion of kainit in the Williamson fertilizer is too high. It is further considered an open question whether the large yields obtained by Mr. Williamson on upland in South Carolina are not due more to the frequent plowing under of a crop of cowpeas, to the liberal use of nitrogenous fertilizers, and to close planting than to the distinctive features of his method. "Our previous experiments lead us most heartily to recommend plowing under a crop of cowpeas or other legumes as a fertilizer for corn, or the liberal use of nitrogenous fertilizers, and in many cases somewhat thicker planting than is customary, but a single year's test does not permit us to recommend all the details of the Williamson method."

CARBON BISULPHID FOR KILLING SASSAFRAS SPROUTS.[a]

Grubbing is a laborious and expensive operation, as all know who have had experience with this means of ridding land of sprouts and small growths of various kinds. This is especially true of growths like sassafras, for example, having extensive root systems which it is almost impossible to entirely remove from the soil by grubbing, and which consequently send up new sprouts every year, making grubbing a perennial task. In experiments at the Arkansas Experiment Station on methods of managing and caring for apple orchards E. Walker found that a great deal of grubbing was necessary to keep the orchard free from sassafras sprouts, and therefore sought to find a substitute for the process. Experiments were made with various substances, including coal tar, salt, and carbon bisulphid.

The results were only partially successful with the first two substances, but entirely satisfactory with the carbon bisulphid. [The carbon bisulphid was] applied to the lower parts of the stem July 20. On the sprouts 3 to 5 feet tall a teaspoonful to a tablespoonful was used. It was poured down the stem, beginning 6 inches above the ground. This portion of the stem turned brown in a few days. The top of the plant was brown and dead in a short time. At the end of the month several were dug up in order to examine the root. They were old roots in some instances which had been cut off several times before. The roots treated with the carbon bisulphid were dead to the end of the roots taken out, the heartwood being discolored.

---

[a] Compiled from Arkansas Sta. Bul. 91, p. 193.

This material costs 10 to 20 cents a pint. It would be more expensive to use it than the grubbing hoe, but it would be cheaper in the end for the scattering sprouts, which persist in pushing up in spite of the grubbing hoe.

While experiments were made only with sassafras sprouts, there is good reason to believe that the carbon bisulphid would prove effective in destroying other kinds of sprouts.

In using the carbon bisulphid it should be borne in mind that both the liquid and the fumes which it gives off freely are inflammable and explosive when brought in contact with fire.

SOLUBLE OILS FOR THE CONTROL OF SAN JOSÉ SCALE.[a]

Within the past two or three years several of the experiment stations have been giving some attention to the nature and value of soluble oils as insecticides for use against scale insects. Soluble oils is the term used to denote compounds of petroleum so treated as to mix readily with water. As suggested by Dr. J. B. Smith, of the New Jersey Experiment Station, they might, therefore, be more properly called miscible oils. The soluble oils thus far used are proprietary preparations and have been compared with mechanical mixtures of petroleum and water and also with lime sulphur and other insecticides.

The chief advantages claimed for soluble oils are ease of preparation, great spreading and penetrating power, and absence of corrosive effects upon machinery and operators. In Virginia one of these soluble oil preparations was tested in a 5 per cent solution. At this strength it seriously injured the foliage of apple trees and failed to destroy the San José scale in a satisfactory manner. The preparation ready for spraying cost from 13 to 15 cents a gallon, as compared with 1 cent a gallon for lime-sulphur wash. Similar results were obtained by Mr. H. A. Gossard at the Ohio Experiment Station. In the opinion of this entomologist, soluble oils will probably prove valuable for use in small orchards and on apple trees with rough bark. "When safety, cost, and efficiency are all considered, we believe lime sulphur is the best remedy for the orchardist to use."

---

[a] Compiled from New Jersey Stas. Bul. 186; New York State Sta. Bul. 281; Ohio Sta. Circ. 60; Virginia Sta. Bul. 152.

Mr. Gossard feels unable to recommend the soluble oils as highly as lime sulphur until more experiments have been carried on with the proprietary compounds.

P. J. Parrott, H. E. Hodgkiss, and F. A. Sirrine, of the New York State Station, report the results of experiments which showed that miscible, or soluble, oils in the proportion of not less than 1 part of oil to 10 or 15 parts of water destroyed a large percentage of scale, but were not quite so efficient as boiled lime-sulphur wash.

They call attention to the fact that "the miscible oils are commercial insecticides and therefore the orchardist should understand that the reliability of the stock material rests with the compounder."

These sprays are simple to prepare for use, and are convenient preparations for the treatment of odd trees and small orchards. The cost of the miscible oils in the proportions of 1 part to 10 or 15 parts of water makes their use almost prohibitive for commercial orchardists who desire a safe and comparatively cheap oil spray.

INDIAN CORN AS A FOOD FOR MAN.[a]

Indian corn and the products made from it constitute a very important part of the available food supply of American families, though the use of corn is by no means limited to the Western Hemisphere. It is also extensively used in Italy, the Balkan regions, China, India, South Africa, and other countries.

Corn meal is undoubtedly the principal food product derived from corn, but large amounts of hominy, hulled corn, corn grits, flaked corn, and various parched and specially prepared breakfast foods are also eaten. Corn starch is a staple food product and corn flour is used to some extent. Unripe ears are extensively used as a vegetable and canned green corn is an important food product. In earlier times corn was dried or evaporated for winter use and such products are still used in a limited way. Pop corn is grown in large quantities and though sometimes used as a breakfast food, in the preparation of puddings, etc., is most commonly eaten out of hand. Corn oil, expressed from the germ, has possibilities as a food product and corn sirup or glucose, made by inverting the cornstarch, is much used as a table sirup, in the manufacture of confectionery, and in other ways. An infusion of parched corn makes a fairly palatable "cereal coffee," or coffee substitute.

At the Maine Agricultural Experiment Station the value of Indian corn as a food has been studied for some time. As Prof. L. H. Merrill points out in a recent publication on the subject, the excellence of Indian corn as a food seems to have quickly impressed itself upon the early settlers and from the first this grain has been closely identified with the history of the American colonists.

---

[a] Compiled from Maine Sta. Bul. 131.

Corn is a native of the Americas and has been cultivated by the aboriginal inhabitants of the New World for many centuries. It was the principal food plant raised by the Indians, though beans, pumpkins, and some other crops were also grown. So extensively was corn used in early times by the American colonists that the word corn, which formerly signified any cereal food grain, soon lost its original significance and was applied exclusively to Indian corn, although the wider use of the term is still retained in Great Britain. In South Africa corn is called " mealies."

> It was a long time before this grain ceased to be the most important of our food cereals; indeed, it is scarcely a century since wheat has assumed the leading place to which its superior bread-making qualities entitle it.
>
> Although Indian corn now occupies the second place in importance among the cereals which in this country serve as food for man, it far exceeds wheat in the size and value of the crop produced. * * *
>
> In 1905 there were in the United States 94,000,000 acres in corn, and the crop attained the almost incredible size of 2,707,993,540 bushels, with a value of $1,116,696,738. In the same year 47,854,079 acres were given up to wheat, and the crop was 692,979,489 bushels, worth $518,372,727. * * *
>
> Of course, but a small fraction of this amount is utilized as human food. There are no reliable statistics to show how much is thus consumed, but it is doubtful if it exceeds 1 bushel in 50 of the total crop. Its use to-day is much more general in the South than in New England, where for the most part it is eaten only at irregular intervals as brown bread, johnnycake, or occasionally as hominy. The colonists, following the example of the Indians, ate parched corn, either entire or in the form of a coarse meal. * * *
>
> Other dishes which found favor with the colonists, composed wholly or in part of corn, were hominy, hasty pudding, johnnycake, brown bread, pone, samp, and succotash, the last consisting of green corn cooked with beans. Although wheat has so largely replaced corn, it may be questioned whether we can not profitably make a fuller use of the cereal which seemed to conduce to both the physical and intellectual vigor of our forefathers.

In connection with the investigations at the Maine Experiment Station, corn and various corn products were analyzed in comparison with wheat flour, average results being shown in the table which follows:

Average composition of corn, corn products, and wheat flour.

	Water.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion, per pound.
				Crude fiber.	Nitrogen extract.		
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Calories.*
Corn	10.75	10.00	4.25	1.75	71.75	1.50	1,796
Hominy	10.96	9.44	.67	.87	78.24	.82	1,808
Corn meal, unbolted	10.80	7.50	4.20	65.90		1.20	1,544
Corn meal, bolted	11.60	8.40	4.70	74.00		1.80	1,728
Granulated meal	11.79	8.50	.98	.46	77.79	.48	1,734
Do	7.77	8.69	1.92	.40	80.72	.50	1,825
Wheat flour	11.09	11.37	1.83	.13	75.44	.64	1,771

The corn meal formerly found upon the market consisted merely of unbolted ground corn, the composition of which was practically identical with that of the grain from which it was prepared. Such meal was commonly sifted before it was used, the bran and other coarse particles being thus removed. While such meal may still be found upon the market, being extensively used as food for stock, that used as a food for man is generally bolted before the meal leaves the mill, the offals or bran being sold as cattle food. Since the fat or oil, so abundant in corn, is confined largely to the germ, and since the oil is peculiarly subject to changes resulting in rancidity, the presence of the germ is prejudicial to the keeping qualities of the meal. This has led to the production of the so-called "granulated corn meal," obtained by the use of roller mills. Instead of reducing the kernel to the desired fineness by a single operation, it is first crushed by a machine known as a "degerminator," which so loosens the germ and hull that they may be removed before the final grinding. It is evident that the composition of the product thus obtained will differ in several very important respects from that previously described, being poorer in fat, through loss of the germ, and also poor in crude fiber or woody matter, which is found for the most part in the rejected outer coating, or the bran. These differences are well shown in the above table. In the manufacture of hominy the germ is also removed, with marked effect upon the proportion of fat in the product. It will be noted that in the manufacture of both hominy and granulated corn meal two-thirds or more of the ash constituents are removed. While small amounts of these salts play a very important part in the animal economy, there is reason for believing that the most of our foods carry them in such large excess that the removal of a part of them in this case is no cause for uneasiness.

Using the corn products whose composition is shown in the above table, the digestibility of hominy, hasty pudding, and corn bread of different sorts was studied with healthy young men as subjects.

The hasty pudding was prepared by stirring the meal into salted water and cooking in a double boiler. In both johnnycake and brown bread equal weights of meal and flour were used. * * *

The brown bread was steamed in tin cans made for the purpose, somewhat conical in form, and provided with covers. Four loaves were cooked at once, the cans being immersed to half their depth in boiling water in a large pan having a perforated false bottom and a cover with a small opening. * * *

Neither flour nor baking powder was used in the preparation of the hoecake. The hot meal was stirred with boiling water until a thick pudding was formed, which was then spread in thin sheets upon the hot, well-greased iron plates and baked at once. In all the work care was taken to insure thorough cooking.

For purposes of comparison, digestion experiments were also made with wheat-flour bread. The special foods studied were eaten with milk and sugar, this ration being termed a simple diet, and as a part of a more elaborate "mixed ration," which also included canned peaches and meat. The following table shows the average coefficients of digestibility obtained for the entire rations and the calculated digestibility for the special food products alone.

Coefficients of digestibility of a ration containing corn products and one consisting of corn products alone.

Kind of food.	Entire ration.			Corn products alone.		
	Protein.	Carbohydrates.	Heat of combustion of digested material.	Protein.	Carbohydrates.	Heat of combustion of digested material.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Hominy in simple diet	89.2	99.0	96.4	84.3	98.2	94.4
Hominy in mixed diet	93.6	98.8	96.3	....	....	....
Hasty pudding in simple diet	89.2	99.0	95.9	88.9	98.3	93.1
Hasty pudding in mixed diet	94.0	98.9	96.9	....	....	....
Johnnycake in simple diet	94.9	98.7	93.8	93.2	98.9	93.5
Johnnycake in mixed diet	94.8	99.3	93.9	....	....	....
Brown bread in simple diet	94.7	98.7	93.5	92.8	98.6	93.4
Brown bread in mixed diet	95.5	99.4	92.9	....	....	....
Hoecake in simple diet	93.9	98.7	93.7	88.9	98.6	93.8
Hoecake with sirup	92.6	99.2	95.5	90.0	98.7	94.0
Hoecake in mixed diet	94.6	98.8	92.6	....	....	....
Wheat bread in simple diet	94.0	98.9	94.0	89.8	98.9	94.0
Wheat bread in mixed diet	96.1	99.0	98.2	....	....	....

In every case but one the protein of the mixed diet was more completely digested than that of the simple diet. The low digestibility of a simple diet has been often noted in previous experiments. With a simple diet the protein of the johnnycake and the brown bread seems to have been slightly more digestible than that of the white bread. With the mixed diet, the white bread shows a digestibility distinctly greater than that of the corn breads.

The use of sirup with the hoecake to a slight degree depressed the digestibility of the protein. This is in accordance with other experiments in which the digestibility of the protein apparently varied with the ration existing between the protein and the other nutrients. * * *

The use of large amounts of butter, pork, or other fatty foods in connection with corn foods is to be deprecated, since the difficulties in the way of establishing a proper balance between the protein and other nutrients is thus increased. The effect of sirup in depressing the digestibility of protein has already been alluded to. Sugar and molasses are open to the same objection and for the same reason. The craving for these food accessories [in such large amounts] is an example of the fact that the appetite is not always a safe guide.

The coarsely milled forms in which corn is placed upon the market naturally call for more prolonged cooking, not only to break down the starch grains, but to rupture the walls of the cells, and thus expose their contents to the action of the digestive juices. It is probable that much of the difficulty occasionally experienced in digesting corn breads might be avoided by a careful attention to these facts. At present there is but little difference to the consumer in the retail cost of corn meal and wheat flour. Both are among the cheapest of our foods. The question of economy need not be considered in choosing between the corn and wheat breads. In general it may be said that the corn products are more digestible than is commonly supposed. Not only their digestibility, but their cheapness and the readiness with which they may be converted into palatable foods suggest a more extended use and entitle them to a much higher place in the popular estimation.

The characteristics of breakfast foods prepared from corn an the composition and digestibility of such materials as compare with breakfast foods made from other grains and related question are taken up in a Farmers' Bulletin of this Department, entitle "Cereal Breakfast Foods."[a]

STORING PRESERVES, CANNED FRUITS, AND CANNED VEGETABLES.[b]

Mrs. L. H. Adams and E. P. Sandsten, at the Wisconsin Experiment Station, have made a number of studies of home methods o canning and preserving fruits and vegetables and have paid especia attention to the use of such native fruits as wild plums and seedlin apples. In connection with this work, considerable attention ha been devoted to methods of handling and storing the canned good in order that they might not deteriorate in quality.

It appears that the condition of the fruit when preserved has marked effect upon the keeping quality of the product.

> It is important that the fruit intended for canning should be in the righ stage of ripeness. This stage is difficult to describe, though in general th fruit should be firm, having attained its full size and normal color. It shoul be free from all kinds of blemishes, such as scab, rust, rot, and all forms o insect life. Fruit intended for canning in any way should be utilized as soo as possible after it is picked. If left standing for hours, even if the fruit i not overripe, the fine flavor is lost and the keeping qualities greatly impaired.
>
> In selecting fruit for canning it is advisable not to mix the different varietie together—for example, if plum preserves are made each lot should be mad from a distinct variety or a combination of flavor will be the result; beside some varieties require more heat than others, thus giving the preserved produc a lack of uniformity so undesirable.

Vegetables intended for canning and pickling should be picked a a suitable stage of ripeness and should be of uniform size and quality For instance, in canning tomatoes the fruit should all be equally rip and of good color, yet should not be overripe. Corn for cannin should not be too tender and watery and, on the other hand, shoul not be so old that it is glazed and tough. For making pickles youn cucumbers are generally considered more satisfactory than the large sizes.

As regards the question of storage, the bulletin referred to says:

> The keeping qualities of preserved fruits and vegetables are greatly impaire by being stored in full daylight. This is especially true when glass jars ar used. The jelly will soon become cloudy and dark when thus exposed. Marmalade and other preserves are apt to sour and become moldy. No matte how well the fruit has been put up and how carefully sterilized and sealed slow changes in the preserve will take place which sooner or later work thei destruction.

---

[a] U. S. Dept. Agr., Farmers' Bul. 249.

[b] Compiled from Wisconsin Sta. Bul. 130.

The careful housekeeper will keep close watch over her preserved fruits, and if indication of spoiling appears the tops should be removed and all mold and spoiled fruit removed and tops again replaced, after which the jars should be resterilized by placing them in a pan of cold water, with cover over, and then gradually apply heat until the boiling point is reached.

There are a number of excellent makes of fruit jars on the market. The main point to bear in mind in selecting jars is that the tops or covers fit tightly, as the fruit will not keep in leaky jars. Jars with large mouths or mouths of the same size as the rest of the jar are preferable to jars with small mouths, as it is much easier to put in the fruit and to take it out. A clear glass jar is preferable to one of colored glass, as one can watch the keeping qualities of the preserves much better.

Several simple devices for tightening and for opening cans are now on the market, which are used in much the same way as a wrench is used for tightening or loosening bolts. Such devices do away with the difficulty often experienced in opening glass fruit jars with metal tops.

In the above discussion no reference has been made to the use of tin cans for home canning, yet they are often used, particularly when some one of the home canning outfits is employed to sterilize the fruits or vegetables. The use of an inexpensive canning outfit is described in an earlier bulletin[a] of this series.

When preserved fruits and similar goods are manufactured on a wholesale scale, tin cans are more commonly used in the United States than glass or earthen jars, though many manufacturers put up certain special grades in glass. In Europe the preference is decidedly in favor of the earthen or glass jars. A recent German publication[b] specifies a number of qualities which a serviceable preserve jar for commercial use should possess. The jar must be provided with a simple sealing device which must be unobjectionable from the standpoint of hygiene and serviceable from the manufacturer's standpoint. Whether a machine should be required for sealing the jars or whether the jar is self-sealing is of secondary importance. A method of sealing jars is to be preferred which enables one to determine whether or not the contents of the jar are spoiled. The jars must be well adapted for use on a large scale and must be reasonably cheap. Little stress is laid by the manufacturers on the possibility of using the jars again. Indeed, so far as can be learned, American manufacturers do not collect the jars or bottles for use a second time. The cover must fit in such a way that after the can has been opened it will still protect the contents from dirt and contamination. The jar must be of such shape and made of such grade of glass that the contents present a pleasing appearance and remain of good quality. It must be of such shape that it can be packed for shipping purposes with a minimum waste of space.

---

[a] U. S. Dept. Agr., Farmers' Bul. 259.

[b] Konserv. Ztg., 1906, No. 41; abs. in Pure Products, 3 (1907), No. 1, pp. 24, 25.

NATURAL AND ARTIFICIAL INCUBATION OF CHICKENS.[a]

Climate must always be an important factor in poultry raising, and it is self-evident that the practice which is successful in Maine or Canada may well be different from that suitable for Virginia, West Virginia, or some other State with a still warmer climate. At the Rhode Island, Utah, West Virginia, and other experiment stations the relative value of natural and artificial methods for hatching chickens has been studied with a view to developing methods which will enable the poultry raiser to hatch chickens in large numbers under profitable conditions. The Ontario Agricultural College in connection with its poultry work has also devoted much attention to the question of incubators and various methods concerned with natural and artificial methods of hatching poultry.

In order to raise chickens successfully, whether by natural or artificial methods, it is very essential to secure eggs which will hatch well and produce strong, vigorous chicks. As Stewart and Atwood, of the West Virginia Experiment Station, pointed out—

> If the germs are naturally weak no amount of attention and good care during the incubation of the eggs and the brooding of the chicks will make up for the original lack of vigor. In spite of all that can be done the hatch will be poor, if the germs are weak, and many of the chicks which do hatch will die. As one can not determine by an examination of the unincubated egg whether the germ is strong or weak, the only thing that can be done in practice is to select the breeding stock with such care and give it such attention that eggs suitable for hatching must of a necessity result.
>
> Breeding stock should be mature. The first eggs laid by pullets should not be used, but when the eggs have attained their normal size and the fowls have reached the age of 1 year or more the eggs should hatch well, provided that all of the other conditions which influence the production of fertile eggs are favorable.

The fowls should be fed a sufficient amount of a ration containing the proper proportion of the different food elements required. Green food, grit, pure water, pure air, and the opportunity to take exercise are all important.

That chickens may be raised in large numbers by the natural method is shown by the tests in Rhode Island and Massachusetts, particularly in the former State. Where this method is followed the chicks are hatched largely during the months of May and June, and when from 50 to 1,500 hens are kept there is little difficulty in securing a sufficient number of broody hens. Many of those who are keeping large numbers of hens seem satisfied with the natural method of incubation, yet there is little doubt that the number of incubators in use is increasing from year to year.

---

[a] Compiled from Maine Sta. Bul. 100; Rhode Island Sta. Rpt. 1903, p. 269; West Virginia Sta. Bul. 98; U. S. Dept. Agr., Bur. Anim. Indus. Bul. 90; Ontario Agr. Col. and Expt. Farm Bul. 151; Cornell Countryman, 3 (1906), No. 6, p. 139.

In a series of incubation experiments at the Rhode Island Station 8,677 eggs were set in incubators. Of these, 86 per cent were fertile, and 46 per cent of the fertile eggs, or 38.6 per cent of the total number of eggs, hatched, the efficiency of hatch under various conditions of management ranging from 0 to 84 per cent.

Whether it will pay to use incubators and brooders for hatching chickens depends very largely upon circumstances. Where chickens are wanted earlier than April 15, Prof. W. R. Graham, of the Ontario Agricultural College, considers that under Canadian conditions an incubator is practically a necessity, as it seldom happens, in northern regions, at least, that any considerable number of hens become broody until after the 1st of April. Again, if it is desired to hatch more than 150 chicks, an incubator is, in many cases, considered cheaper and better than the natural method, and is a necessity when nonsetting varieties of hens are kept.

In Professor Graham's opinion, on an average the incubator will hatch as large a percentage of eggs as the hen, though there is little doubt that certain hens will hatch a higher percentage than the machine. Tests carried on at the Ontario Agricultural College have shown that when 240 eggs were placed in an incubator and the same number under 20 hens the number of chicks hatched was about equal.

> The average hatch is probably one chicken from every two eggs set. This, of course, varies with the different seasons, also with the percentage of fertile eggs, and the strength of the germ. We have found during the months of February and March, when the ground is covered with snow and the fowls are closely housed, that the percentage of fertile eggs is small, and that the germs are very weak. Under such conditions we have very poor hatches and chicks that are very hard to rear. Much better eggs are obtained in December and early January, or when the fowls get out into the fresh air and are able to pick some grass. Thus it will be seen that, as a general rule, as the percentage of fertile eggs increases, the vitality of the germ increases, the percentage hatched is larger and the mortality among the young chicks smaller. For example, we would expect to get a much larger percentage hatch of the fertile eggs from eggs that were 90 per cent fertile than from those that were 60 per cent fertile; and, moreover, we would figure on raising a much larger percentage of chicks from the former eggs than from the latter, owing to the chicks being stronger and having greater vitality.

When hens are used to hatch the eggs it is generally conceded that in order to secure the best results the hen must be placed where other poultry will not disturb her.

> As a rule, we seldom get good hatches where other hens lay in the nest with the sitter. Some farmers do not set a hen until one becomes broody on a nest where no others lay, which often necessitates late chicks. The difficulty can be

overcome by making a new nest for the broody hen. Get a box about 12 inches square and 6 inches deep; put some earth, or an overturned sod, in the bottom, taking care to have the corners very full so that no eggs can roll out from the hen and get chilled; next put on about 2 inches of straw or chaff; and then put a few earthen eggs into the nest. Place the nest in some pen where nothing can disturb the hen, and put her on after dark. Feed and water must be within easy reach, and a dust bath should also be convenient. If the hen is * * * [on the nest the next day and quiet], you will be safe in putting the eggs under her. In our experience we get 90 per cent of the hens to sit by following this method.

It should be remembered that the hen will be in better condition if dusted with insect powder when set, and also a few days before the hatch comes off. This will usually keep the lice in check, especially if some tansy or mint leaves are used in making the nest.

As Professor Graham points out, little definite information is available regarding the management of incubators, some persons succeeding in obtaining large hatches while others, under apparently the same conditions, meet with failure. The real reason for this variation is not known. "This much, however, can be said: The machine should not be placed in a direct draft, nor yet in a building where there is a lack of ventilation. Fresh air is one of the most important things in an incubator room. * * * Hardly any two people agree as to which is the best place to operate the machine," good hatches being sometimes obtained in cellars, in kitchens, and in other rooms.

As a general rule it is wise to follow the manufacturer's directions in managing an incubator. The Canadian work shows "that different makes of incubators require different treatment, both as to temperature and otherwise, and we generally get the best results when running closely to the directions. Where possible the temperature in the room should vary but little; for if it varies 30° to 40° in twenty-four hours it is very hard to keep an even temperature in the machine, and it is absurd to expect that the machine will not vary with such changes in the surrounding temperature."

According to G. M. Gowell, of the Maine Experiment Station—

Incubators have been so much improved that there are several kinds on the market that will hatch as many chicks from a given lot of eggs as can be done by selected broody hens. They require little care, maintain an even temperature, and are easily adjusted to meet the increase in temperature arising from the developments going on in the eggs. In some machines the moisture supply is automatic and adapted to the requirements; in others it has to be supplied, and skill is necessary in determining the quantity needed. The economy of the incubator is very great. A 360-egg machine will do the work of nearly thirty broody hens and can be kept at work continually if desired.

In this connection it is interesting to consider some work carried on at Cornell Agricultural College to determine how frequently the sitting hen turns her eggs. From a considerable number of observations it appeared that in every instance the eggs were moved about two or three times a day by the hen and did not remain in the same part of the nest for more than three days. " The thorough manner in which the hen turns the eggs may well furnish us a clew to the most natural and proper treatment of the eggs when under the artificial conditions of the incubator."

Chickens hatched in an incubator can be reared either with hens or with a brooder. Professor Graham considers the use of broody hens for mothers preferable.

> The best plan to get the broody hens to take the chicks is to give the hen two or three eggs out of the incubator on the eighteenth or nineteenth day and allow her to hatch them. When your incubator hatch is over take a dozen or fifteen chickens and put them under the hen after dark. Even if they happen to differ in color from those she has hatched she will mother them all the same. If you give them to her in the daytime, she may not do so. Never neglect to give the hen a thorough dusting before giving her any eggs. If there is one thing more than another that requires careful attention in rearing young chickens, it is to keep them free from lice. If lice get upon them, from the hen or elsewhere, a large proportion of them will be almost sure to die.

At the Maine Station brooders have proved very satisfactory, and indoor brooders are preferred. " The style used has the cover and part of one side arranged to turn down, making an inclining run the whole width of the brooder, up and down which the little chicks can go without crowding.

" Most kinds of brooders as now made keep the chicks comfortable at desired temperatures and have good means of ventilation."

" In brooding chicks," as Stewart and Atwood point out, " either in individual brooders or in brooder houses, the main thing which must be watched is the temperature, for if the temperature is either too high or too low the results will be totally unsatisfactory, even though all of the other conditions governing the health of the chicks are ideal." * * *

> The temperature of the brooder or brooder house when the chicks are first transferred from the incubator should be practically as high as the temperature of the incubator from which the chicks have just been removed, or from 95° to 100° F. This temperature should be maintained for the first week, never allowing it to fall below 95°. The second week the temperature should not be allowed to drop lower than 90°. These temperatures refer to the air temperature taken on a level with the chicks. After the second week the temperature should be reduced gradually until the chicks are old enough and hardy enough to do without artificial heat.
>
> Where the chicks are to be raised on a large scale the brooder house heated by hot water pipes is the most economical, for in this case there is only one fire to attend, and the work of feeding and watering the chicks can be done much easier than when the chicks are scattered about in individual brooders.

The Department of Agriculture has recently published a Farmers' Bulletin entitled " Incubation and Incubators," by R. H. Wood,[a] which summarizes much useful information regarding incubator construction, management, and related questions.

---

[a] U. S. Dept. Agr., Farmers' Bul. 236.

BARE-LOT METHOD OF RAISING LAMBS TO AVOID NODULE DISEASE.[a]

A parasitic worm known to scientists as *Œsophagostoma columbianum* causes the appearance of nodules in the intestines of sheep. This worm is generally distributed throughout the United States, and becomes a serious scourge in the sheep business, especially when conditions are favorable for the infestation of young lambs. It has been shown by the Louisiana Experiment Station that when sheep infested by this parasite are placed on clean pasture and allowed to remain for some time the pasture becomes contaminated and will cause an infestation of healthy sheep which may subsequently graze upon it. It was also found that when an infested pasture was plowed up and cultivated for one season danger of infestation with the parasitic worm which causes nodule disease was entirely removed.

This indicates a successful method of treating infested land. On account of the wide distribution of this parasite, however, and the general infestation of breeding ewes, it was desirable to find a method by which lambs could be raised from these ewes without becoming seriously infested with the parasite.

In order to accomplish this purpose a bare-lot system was adopted. This consists simply in keeping the ewes with their lambs on a plat of ground from which all grass or other green vegetation has been removed. The lambs, therefore, have no temptation to pick up anything from the ground and do not run the risk of infesting themselves with the nodule-producing parasites which may be upon the ground. In the experiments carried on at the Louisiana Station the ewes were fed grain once a day, and a rack was provided for feeding green forage of different kinds. All green forage which was pulled out of the rack by the sheep was carefully removed from the feed lot each day. Fresh water was always present in a wooden trough, and the feed lot was leveled so as to prevent the accumulation of water in pools from which the lambs might drink. In this feed lot nine ewes were placed with six lambs, the lambs being born in February and March. At the end of June, all lambs being weaned, the ewes were slaughtered and all found to be infested with the parasitic worms. The lambs were slaughtered and carefully examined at ages varying from 88 to 155 days. In three of these lambs two or three nodules of minute size were found in the intestines. The others were entirely free from nodules, but all six of the lambs were infested to a greater or less extent with stomach worms. The infestation of stomach worms, however, was not sufficient to influence perceptibly the development and fattening of the lambs. It is difficult to understand how infestation with stomach worms took place. The bare-lot method appears, from these experiments, to give promise as a means of raising lambs for market at an early age from mothers infested with the nodule-producing parasite without danger of serious infestation of the lambs. It is recommended that in addition to maintaining the infested ewes with their lambs in a bare lot the lambs should be given some vermifuge with their food, or at least common salt, to assist in the removal of possible stomach worms.

---

[a] Compiled from Louisiana Stas. Buls. 79, 83, 89.

SOME MILK TERMS.[a]

The following notes are offered in the nature of explanations of certain terms which, though very frequently heard among dairymen and regularly met with in dairy literature, are nevertheless often used inaccurately and sometimes in a way intentionally misleading.

The many terms, such as aerated milk, filtered milk, etc., which are everywhere well understood are not included. Other terms, such as malted milk and lacto preparations, are omitted because they apply to manufactured food products rather than to forms of milk.

Standard milk.—The variable nature of milk makes it impossible to state without chemical analysis the quantity of fat or other constituents to be found in any given sample. While numerous factors such as the breed of cows and the stage of lactation affect the composition of the milk, the variations, nevertheless, are within limits capable of being defined with sufficient accuracy and fairness for practical purposes. Nearly every country has found it necessary to establish in one way or another certain minimum requirements. Milk to be considered unadulterated in Great Britain, for instance, must contain 3.5 per cent of milk fat and 8.5 per cent of solid matter other than fat. In this country the requirements vary in the different States. In matters concerning the National Government, milk in order to be designated standard must conform to the following definition proclaimed by the Secretary of Agriculture:

"Milk is the fresh, clean, lacteal secretion obtained by the complete milking of one or more healthy cows, properly fed and kept, excluding that obtained within fifteen days before and ten days after calving, and contains not less than eight and one-half (8.5) per cent of solids-not-fat, and not less than three and one-quarter (3.25) per cent of milk fat."

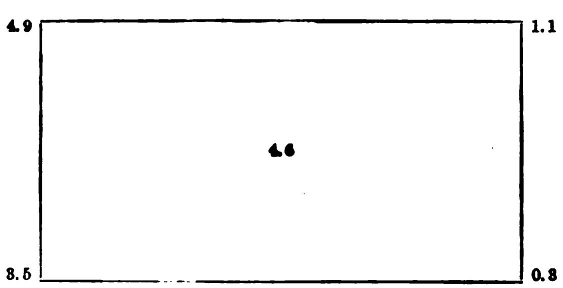
Standard milk is therefore milk which conforms to certain requirements. These are commonly but not always of a chemical nature. In some cities bacteriological standards have been established. These specify usually a maximum number of bacteria per cubic centimeter allowable in milk offered for sale.

---

[a] Compiled from various sources including Alabama Col. Sta. Bul. 97; Illinois Sta. Buls. 75, 92; New Hampshire Sta. Bul. 103; Michigan Sta. Bul. 228; U. S. Dept. Agr. Circ. 19.

Standardized milk, Blended milk.—These terms are applied to milk which has been so modified as to contain a definite amount of one or more of its constituents. The most important and at the same time the most variable constituent is fat. To standardize milk as regards fat it is simply necessary to add or remove a certain amount of this constituent or to add or remove a certain amount of skim milk. Detailed directions for this purpose are given in Bulletin 75 of the Illinois Station. To cite an illustration from this bulletin, 1,600 pounds of milk containing 3.2 per cent of fat may be standardized to 4 per cent of fat by removing 320 pounds of skim milk. A simple method of determining the amounts of skim milk and whole milk, or of milks containing different percentages of fat which should be mixed in order to secure a product having a desired fat content is given by Prof. R. A. Pearson in a reading-course bulletin of Cornell University.

> Draw a rectangle and write at the two left-hand corners the percentages of fat in the fluids to be mixed, and in the center place the required percentage. At the upper right-hand corner put the number which represents the difference between the two numbers standing in line with it—i. e., the number in the center and the one at the lower left-hand corner. At the lower right-hand corner put the number that represents the difference between the two numbers in line with it. Now let the upper right-hand number refer to the upper left and the lower right hand to the lower left, then the two right-hand numbers show the relative quantities of the fluids represented at the left-hand corners that must be combined to give a fluid of the desired standard which is represented in the center. * * *
>
> If it is wanted to mix the milks from two dairies testing 4.9 per cent fat and 3.5 per cent fat to produce a 4.6 per cent milk, the diagram shows these milks must be mixed in the proportion of 1.1 to 0.3 or 11 to 3. Thus:



> If we have 120 pounds of the 4.9 per cent milk we must mix with it 32.7 pounds of 3.5 per cent milk, as is shown by this proportion: 11:3: :120:32.7.

Modified milk, Humanized milk.—These terms are applied frequently to cow's milk specially prepared for infant feeding. The most important difference between cow's milk and human milk lies in the proteids or nitrogenous constituents which are greater in amount in cow's milk. By allowing cow's milk to stand for several hours, taking the top portion, and diluting this with water with the addition of milk sugar, a product may be obtained which corresponds in percentages of fat, proteids, and milk sugar to human milk. The modifications which have been suggested and the ways of making them are very numerous.

Certified milk.—This term, though registered as a trade-mark in 1894, is now quite generally used with reference to milk produced and handled under conditions approved by some responsible organization such as a medical society. An organization of this kind exercises supervision over the health of the cows, the cleanliness of the dairy, the health of employees, the chemical composition and bacterial content of the milk, and other matters having a bearing upon the wholesomeness of the milk and furnishes a dairyman, complying with the specified requirements, a statement certifying to the purity of his product.

Guaranteed milk.—The term " guaranteed " is often applied to milk in its ordinary sense. It merely means that the producer agrees to deliver milk of a certain composition or quality, and it should carry weight only in proportion to the reliability of the party making the guaranty.

Sanitary milk.—This is a term applied somewhat indefinitely to milk produced and handled under conditions considered necessary to secure a pure, wholesome product. It is often applied by dealers, for purposes of advertising, to milk produced under decidedly insanitary conditions. The term " hygienic " is similarly abused.

Pasteurized milk.—This term should be applied only to milk which has been heated sufficiently to destroy most of the active organisms present. Bacteria of one kind or another are invariably present in milk obtained under ordinary conditions. Some of these cause souring of milk, while others may occasionally be disease-producing forms, such as the tubercle bacillus. Milk may be heated enough to destroy all the organisms present, but when this is done it has acquired a cooked taste which is more or less undesirable. To avoid this the temperature of heating should not exceed 185° F., and at the same time to secure the destruction of any considerable number of the organisms present, it must not be below 140° F. When the higher temperature mentioned is used the period of heating may be very short, but when the lower temperature is employed it must be prolonged in order to secure the same results. Pasteurization therefore merely checks fermentation. It does not destroy all of the organisms present. It should, however, destroy all disease-producing organisms likely to gain access to milk.

Sterilized milk.—This is milk in which all organisms have been destroyed. It is not always accomplished by merely boiling the milk unless the boiling is repeated on two or three successive days. Higher temperatures than the boiling point are necessary to assure sterilization or the complete destruction of all organisms at one application of heat of fifteen to thirty minutes' duration. Much of the so-called sterilized milk is by no means free of living organisms.

Clarified milk.—In passing through a centrifugal separator much of the solid impurities in milk remains in the separator slime. A mixture of the skim milk and cream so obtained is often referred to as clarified milk.

Carbonated milk.—This is milk put up in bottles and charged with carbon dioxid or carbonic-acid gas.

Homogenized milk.—This is milk in which the fat globules have been broken up by mechanical means into very fine particles, which show no tendency to rise to the surface, as do the fat globules of ordinary size. In accomplishing this purpose the milk is usually forced through capillary tubes and against a resisting surface. The force of impact causes the breaking up of the globules and thus makes a more perfect emulsion out of the milk. The process is protected by patents in various countries.

Condensed milk, Evaporated milk.—This is defined by the Secretary of Agriculture as milk from which a considerable portion of water has been evaporated and which contains not less than 28 per cent of milk solids, of which not less than 27.5 per cent is milk fat. The sweetened product contains varying percentages of added sugar.

Desiccated milk.—This product, which is usually referred to in this country as milk powder, is prepared from whole or skim milk by patented processes.

O

Issued April 30, 1907.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 282.

CELERY.

BY

W. R. BEATTIE,

Assistant Horticulturist, Bureau of Plant Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

CONTENTS.

	Page.
Introduction	7
Botany of the celery plant	7
Growth of the celery industry	8
Object of this bulletin	8
Climatic and soil requirements of celery	9
Climatic conditions governing the production of celery	9
Soils suited to celery growing	9
Fertilizers	10
Barnyard manure	10
Lime and salt	10
Commercial fertilizers	11
Preparation of the soil	11
Time and method of plowing	11
Smoothing and pulverizing	11
Application of fertilizers	11
Marking rows for planting	11
Seed sowing and plant production	12
Selection of seed	12
Sowing for an early crop	12
Sowing for a late crop	13
Transplanting	14
Watering	14
Moisture requirements of the seed bed	14
Methods of securing and applying water	14
Furrow, or open-ditch, system	15
Sprinkler systems	15
The subirrigation method of applying water	16
Growing celery without irrigation	17
Planting in the open ground	17
Distances to plant	17
Directions for planting	17
Mulching	18
Cultivation	19
Directions for cultivating	19
Maintenance of a dust mulch	20
Diseases	21
"Damping"	21
Celery blight	21
How to combat celery blight	21
Black-rot or heart-rot of celery	22
Insect enemies and their control	22

Page
Methods of blanching 23
  Use of boards for blanching 24
  Use of farm drain tiles for blanching 25
  Use of soil for blanching 26
  Other methods of blanching celery 27
  Blanching for winter use 27
Storing 28
  Banking and covering with straw, etc 28
  Trenching 28
  Storing in cellars 29
  Storing in a celery storage house 30
  Digging, handling, and putting away celery 31
Marketing 32
  Preparing celery for market 32
  Sanitary conditions 33
  Methods of shipping 33
Profits to be derived from celery culture 34
  Cost of production 34
  Estimates of returns 35
Varieties of celery 36
  Varieties for home use 36
  Varieties for market 36

ILLUSTRATIONS.

Page.
FIG. 1. Flat, or tray, for early sowing or for transplanting, with marker for making holes in the soil into which the seedlings are set 12
2. Celery plants, showing effect of transplanting on root system 14
3. Deluge sprinklers in operation; pump house shown on the right 15
4. Cross section of soil, showing arrangement of tiles for subirrigation 16
5. Gardeners setting celery plants in the open ground 18
6. Celery growing in solid beds, showing the method of blanching by shoveling earth between the plants and also the supports used during warm weather for holding muslin shades 19
7. Small-tooth horse cultivator 20
8. Wheel hoe 20
9. Field of celery in process of blanching by means of boards, with a celery hiller in the foreground 24
10. Celery in process of blanching by means of drain tiles 26
11. Celery in process of blanching by means of earth 27
12. Cross section of hotbed pit used for the storage of celery on a small scale 29
13. Cross section of celery storage house 30
14. Celery trimmed, washed, and bunched ready for market 32
15. Packing celery in crates for shipping in the rough in a Florida field during February 34
16. Crate of celery shipped in the rough 35

B. P. I.—264.

CELERY.

INTRODUCTION.

The culture of celery on an extensive scale is limited to comparatively recent years. Many persons can now recall the time when celery was considered a novelty and when it was used only for garnishing and for flavoring purposes. Celery has now become one of the common garden crops, and the commercial demand for it has so increased that the product in the United States is reckoned by hundreds of carloads. Celery is no longer classed as an expensive luxury, but as a wholesome and palatable addition to the fare of the people generally.

Botany of the celery plant.—The many cultivated varieties now in use have been derived from the wild celery, which is a native of the marshes of southern England and many parts of the Eastern Continent. This wild celery was for a long time considered poisonous, a very natural supposition, as it belongs to the same family of plants as Cicuta and poison hemlock.

The Latin or scientific name of celery is *Apium graveolens*, and it belongs to the Apiaceæ, a family of plants formerly known as Umbelliferæ. It is a biennial, producing its seed the second season, after which the plants die. Occasionally a plant will throw up a flower stalk and produce seed the first season, but this occurs only in cases where the growth of the plant has received a severe check or the vitality of the seed was low. As ordinarily grown, the celery plant has no true stem, the first season being spent in the production of plant food, which is stored up in the root, and in the enlarged succulent basal leaves. It is the stalks, or stems, of these leaves which, when blanched, form the edible part. The seeds of celery, also, are very largely used for flavoring salads, soups, and a variety of dishes. The fleshy root of the celery plant is used in soups; it is also prepared as a separate dish, being cut in small pieces, boiled until tender, and then served like asparagus with a dressing of cream.

There is a special turnip-rooted form of celery, known as celeriac, which produces a large root and very small leaf steams. This is more suitable for cooking than the common celery, although the edible portion of the latter makes a very palatable dish when stewed in butter, with salt and pepper to taste. The principal value of celery, however, lies in its excellence of flavor and other desirable qualities when well blanched and served in the raw state.

While celery may not possess much actual food value, it is very attractive, and its use is an important one from the fact that it furnishes an essential vegetable ingredient of a well-regulated diet. Coming as it does at a time of the year when large quantities of meat are consumed and green foods are not plentiful, the use of celery makes other foods more palatable and greatly aids digestion. The taste of celery is at first unpleasant to some persons, but a liking for it is usually acquired after eating it a few times.

Growth of the celery industry.—Celery growing on a commercial scale in this country received special attention and made its greatest progress after the opening and draining of the "muck-bed" areas of the Great Lake region. In Michigan, Ohio, and New York several thousand acres of celery are grown annually. In California and Florida celery growing is now an important industry. New fields for the production of this crop are developing from time to time, and celery is now found in the market throughout almost the entire year.

Celery growing in Florida and California constitutes a different business proposition from its culture in the Northern and Eastern States. Maturing as it does in those warmer climates between the middle of December and April, the crop does not come into competition with that of the northern and eastern territory to any extent, but serves to lengthen the season of celery consumption.

It has not been found profitable in most localities to store celery for any great length of time, it being more satisfactory to load it into the car direct from the field and place it upon the market as rapidly as it becomes blanched. The Northern and Eastern States can supply all that is wanted in a commercial way from early June until about the 1st of January; the Florida and California product comes upon the market about the last week in December and continues until March or April, after which time there is not so great a demand for celery until the northern crop again comes upon the market.

Object of this bulletin.—It is the purpose in this bulletin to deal principally with that phase of the celery industry consisting of its production for home use and to give directions for growing and storing it in small quantities. It has also been found advisable to include such instructions and estimates as would be required by any person wishing to begin the growing of celery for the market.

No argument is necessary in regard to the desirability of having plenty of good, crisp celery for table use. The experimental stage in celery growing, especially as to the determination of its value, has long passed. There remains but one problem, that of securing the supply, and, under most circumstances, the farmer or amateur horticulturist can readily devote a few square feet of rich land to the growing of celery. If the quantity desired is small and there is a market near at hand where celery may be had at all times during its season, it may be more economical to purchase the supply, but the pleasure of obtaining it from one's own garden will more than repay the effort required. Celery purchased in the market can not possibly be as crisp and tender as when dug at home and served on the table within two or three hours without having been handled many times and exposed for sale for a considerable period.

CLIMATIC AND SOIL REQUIREMENTS OF CELERY.

Climatic conditions governing the production of celery.—Climatic conditions have an important bearing upon the production of celery, and the United States is naturally divided into three areas, as follows: (1) The northern area, within which celery may be produced during the summer months; (2) the middle area, within which the weather is too warm and the atmosphere too moist during the summer and too cold in winter for the successful commercial production of celery, and (3) the southern area, within which celery may be grown during the winter months. These areas are further influenced by elevation, proximity to mountains, direction of prevailing winds, and rainfall. There are, however, few sections in this country where it would be impracticable to grow a supply of celery for home use. The ideal climatic conditions for the production of celery are bright sunshine, pure air, cool nights, and a well-distributed rainfall of about 8 inches during the growing period in the field or garden.

Soils suited to celery growing.—In the production of celery for domestic use, a rich, mellow, sandy loam will give the best results. The soil of the seed bed should contain plenty of leaf mold and should be passed through a sieve having not less than six meshes to the inch. The soil of the transplanting bed need not be sifted so fine, and some well-rotted barnyard manure should replace a part of the leaf mold; in other respects it should be the same as that of the seed bed.

Any fertile, well-drained soil will grow celery, but a loose, sandy loam is preferable. In the regions where peat bogs or muck soils abound, the crop may be more easily produced on these than on any other soil, but the keeping qualities are not so good and the flavor is never equal to that of celery grown on sandy loam, or even on clay soils. If nothing but clay soil is available, it may be made to produce good celery by the liberal application of well-rotted barnyard manure. On clay soils there is likely to be injury caused by the soil becoming washed into the hearts of the plants while they are yet small.

Where celery is grown for market, even on a small scale, attention should be given to the maintenance of humus in the soil. This may be accomplished either by the application of large quantities of barnyard manure or by planting the land every third or fourth year to some leguminous crop, such as clover, cowpeas, beans, peas, or soy beans. Celery growing not only exhausts the chemical fertility of the soil, but also injures its physical condition, after a time rendering it unfit for this purpose. Any of the above-mentioned crops will tend to restore the soil to its proper condition.

FERTILIZERS.

Barnyard manure.—For the production of the home supply of celery there is no fertilizer that is so satisfactory as well-rotted barnyard manure. Barnyard or stable manure not only furnishes plant food for growing the crop, but improves the mechanical condition of the soil by the addition of humus. The action of barnyard manure is rather slow, and it is frequently desirable to supplement the manure by an application of commercial fertilizers. In many localities the supply of manure is limited, and it may be necessary to depend almost entirely upon commercial fertilizers. If fresh stable manure is used, it should be plowed under in the autumn. If the manure is well rotted, it may be plowed under early in the spring or used as a top-dressing a short time before planting. If the manure is plowed under, the land should be replowed a short time before planting in order to bring the manure to the surface. From 10 to 20 tons of manure to the acre should be applied each year that the land is planted to celery.

Lime and salt.—The application of lime will improve most soils. Following the use of stable manure an application of 1,000 pounds of ground quicklime as a top dressing will be beneficial. Soils that are liable to leach during the winter can be held by planting to rye and the crop turned under quite early in the spring. If this method is followed, the lime can be applied by means of the fertilizer attachment of a grain drill at the time the rye is sown. When applied to clay soils the lime has a tendency to lighten them, and sandy soils are rendered more retentive of moisture by the addition of lime.

An application of 500 to 800 pounds of common salt to the acre is considered desirable by some growers. Celery will take up a limited quantity of salt, and its flavor is improved thereby.

Commercial fertilizers.—One to 2 tons of high-grade fertilizer to the acre may be profitably applied on most soils in addition to the stable manure and lime. As a rule, the quick-acting fertilizers are used, and a mixture suitable for growing celery should contain about 6 per cent of nitrogen, 5 per cent of available phosphoric acid, and 10 per cent of potash. An excellent plan is to drill a part of the fertilizer into the land by means of the fertilizer attachment of a grain drill, and then scatter the remainder in the rows and work it into the soil by means of a harrow or cultivator. In the preparation of the rows for growing the home supply of celery, it will be sufficient to apply between 2 and 3 quarts of high-grade fertilizer to every rod of row to be planted, working the fertilizer into a strip of soil 12 to 18 inches in width. After the celery plants have become well established their growth may be hastened by making frequent light applications of nitrate of soda to the surface of the soil before cultivation.

PREPARATION OF THE SOIL.

Time and method of plowing.—As a rule the land should be plowed several weeks before planting. At the North it is desirable to plow the celery land in the autumn and allow the soil to lie exposed to the action of frost during the winter. At the South it will be necessary to plow but a short time before planting. The plowing should be very thorough, and in most cases with a somewhat heavier plow than that generally used for other crops.

Smoothing and pulverizing.—A few days before the land is required for planting, the surface should be cut with a disk or cutting harrow, followed by such tools as are necessary to pulverize the soil to a depth of 5 or 6 inches. Just before planting, the land should either be rolled or gone over with a float, or drag, made by nailing together planks or scantlings, in order to secure an even surface for planting.

Application of fertilizers.—Commercial fertilizers should be applied while fitting the land for planting and should be well mixed with the surface soil. An ordinary grain drill with a fertilizer attachment will sow fertilizer at the rate of about 1,000 pounds to the acre and will be very satisfactory for this purpose. There are a number of fertilizer distributers designed for applying the fertilizer in the row, and some of these are provided with cultivator shovels for mixing the materials with the soil.

Marking rows for planting.—The rows in which the celery plants are to be set should not be marked until a short time before planting, in order that the soil may remain fresh. A marking device similar to the ordinary corn marker may be used, but some form of roller with a number of projecting pegs to form holes in which to set the plants is desirable. A device of this character can be constructed by replacing the wheel of an ordinary wheelbarrow with a roller having a series of pegs.

SEED SOWING AND PLANT PRODUCTION.

Selection of seed.—The first and most important consideration when preparing to grow a crop of celery is the securing of good seed, not merely seed of which a large percentage will germinate, but that having strength and vigor sufficient to give the seedling a good start. As the seeds of celery are very small, it is necessary that only a small percentage of the number usually sown should actually grow in order to secure an abundance of plants; but as low germination and the necessary vigor are seldom both to be found in the same packet of seed that seed which has a high percentage of germination is preferable. Celery seed, like that of parsley, carrot, and parsnip, loses its vitality very quickly and is practically worthless when kept over until the second year. In addition to the above qualities, the seed should be from selected stock and true to name. Place your order for seed early, before the supply of the best grade is exhausted, and there will be little difficulty in getting good seed. Purchase from a seedsman who expects to sell to you again the following year, pay the highest price if necessary, and demand the best.

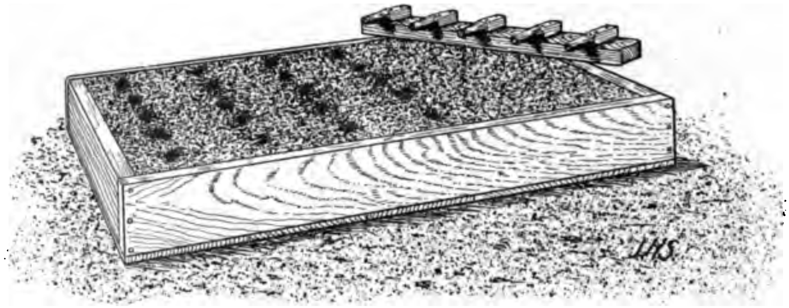


FIG. 1.—Flat, or tray, for early sowing or for transplanting, with marker for making holes in the soil into which the seedlings are set.

Sowing for an early crop.—For sowing seed during the early part of the season, the plan best suited to the requirements of the farmer or amateur grower of celery is to secure a wooden flat or tray (fig. 1), about 16 by 24 inches in size and 3 inches deep, with several small holes in the bottom for drainage. After filling with sifted soil, as previously mentioned for the seed bed, level it off even with the top, and either shake down the soil or press it down by means of a board before the seeds are sown. Either sow in drills 2 inches apart or scatter broadcast, and cover the seed by sprinkling through a fine sieve a very small quantity of leaf mold or sand. This tray can be placed in the window of a moderately warm room in the dwelling, and the soil should be watered by sprinkling very lightly as often as necessary to keep the surface from showing dryness, but the soil should not become waterlogged. The seedlings will appear in from two to three weeks, after which the tray should be turned around once each day to prevent the plants " drawing " toward the light. If early plants are needed on a somewhat larger scale, sow the seeds in like manner in a hotbed or on a greenhouse bench.

Sowing for a late crop.—For later plants, from which the main crop is to be planted, sow the seeds in a cold frame or in the open ground. Several methods are in vogue for starting celery plants in the open ground, and the one selected should depend entirely upon the scale on which the crop is to be grown. One plan is to sow the seed broadcast in a bed about 3 feet wide and of any desired length, from which the plants may be transplanted to another similar bed, and again to the open field, or they may be thinned and allowed to remain in the seed bed until it is time to set them in the open ground where they are to mature. Another method is to sow in drills 10 or 12 inches apart and cover very lightly by sifting soil or by passing a roller along the drill after the seed has been dropped. When the seedlings are well started, they may be thinned out and allowed to remain until planted in the field. Plants grown in this manner require very little attention, as they can be worked by means of a wheel hoe or other hand cultivator.

The method now in use by most large growers is to prepare a tract of land by pulverizing with horse tools and then raking by hand, after which the seed is sown broadcast by means of a wheelbarrow grass-seed drill. The soil is sometimes pressed down with a plank after the seeds are scattered, but some growers maintain that there is a decided advantage in leaving the soil slightly uneven, as the seeds fall into the shaded places and are protected from the direct rays of the sun. The seed will become sufficiently covered by rains or by watering. Should more than 20 per cent of the seed usually sown germinate, it is necessary to thin out to prevent overcrowding, with its attendant injury. To prevent the surface of the soil becoming too dry, it may be necessary to partially shade the young plants during the warm days of early summer, but the shading should never be so dense as to cause them to become " drawn."

For early celery throughout the Northern States a planting should be made in the house during January or February, but for the main crop the seed may be sown in a frame or hotbed or in the open ground six weeks or two months later. In the latitude of Washington, D. C., good celery can be grown from seed sown as late as the middle of May, and to the southward still later.

TRANSPLANTING.

In case the grower adopts the plan of transplanting twice, the seedlings will be ready for the first handling in from four to six weeks from the time the seed is sown. The seedlings may be transplanted to trays (see fig. 1) or to beds in the open ground. This transplanting answers two purposes: (1) The seedling plant of celery has a straight root, or taproot, which is broken in transplanting, causing a large mass of fibrous roots to be formed. In the case of a plant allowed to remain in the seed bed until planting-out time this taproot has gone far down into the soil and the plant has formed very few side roots; consequently it suffers a great shock in the process of planting in the field, and a large number of plants will need to be replaced. (2) When transplanting twice is practiced there is no necessity for thinning, and a more uniform lot of plants is obtained. Figure 2 shows the effect of transplanting, the two plants being from the same seeding. Two handlings can not be recommended when celery is grown on a large scale, as the cost of labor is too great. It is better to have a surplus of plants and to renew those that fail.

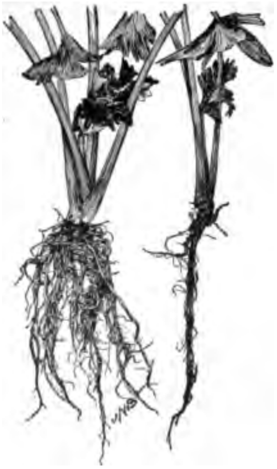


FIG. 2.—Celery plants, showing effect of transplanting on root system.

WATERING.

Moisture requirements of the seed bed.—When the seed bed is prepared, the soil of which it is composed should contain as much moisture as possible and yet be in good condition to handle. After sowing and covering the seeds the bed should be sprinkled lightly. During the period between seeding and the appearance of the plants the bed should be watered only as often as it shows indications of dryness; however, the surface should never become dry. During the first few days a moist cloth may be spread over the surface of the seed bed in order to conserve the moisture, but this covering should be removed before the seedlings begin to appear. After the plants are up, care should be taken not to water too heavily, as the seedlings are liable to "damp off;" but the ground should never become so dry as to check their growth.

Methods of securing and applying water.—No definite rules can be given for the application of water to a growing crop of celery, as the requirements vary with the character of the soil, atmospheric conditions, and temperature. The cost of application should determine largely the extent to which water should be used, and as a rule it is not profitable to give more than three waterings during the growing season in addition to the one given at the time the plants are set in the field. When celery is to be grown on a large scale it will be desirable, where a natural water supply can not be brought into service, to provide pumping machinery and to give the soil two or three good soakings during the season, especially in the absence of heavy rains. Celery requires the most water while making its greatest growth, which occurs late in the summer. As the crop approaches maturity the water should be applied sparingly, and it should be withheld altogether for some time before blanching.

Furrow, or open ditch, system.—Among the methods of applying the water, the most simple and usually the most desirable practice, especially where the surface of the soil is even, is to run the water along the rows by means of small furrows, 8 or 10 inches distant on either side of the row. This method is well adapted to use on a gentle slope with the rows running up and down the incline.

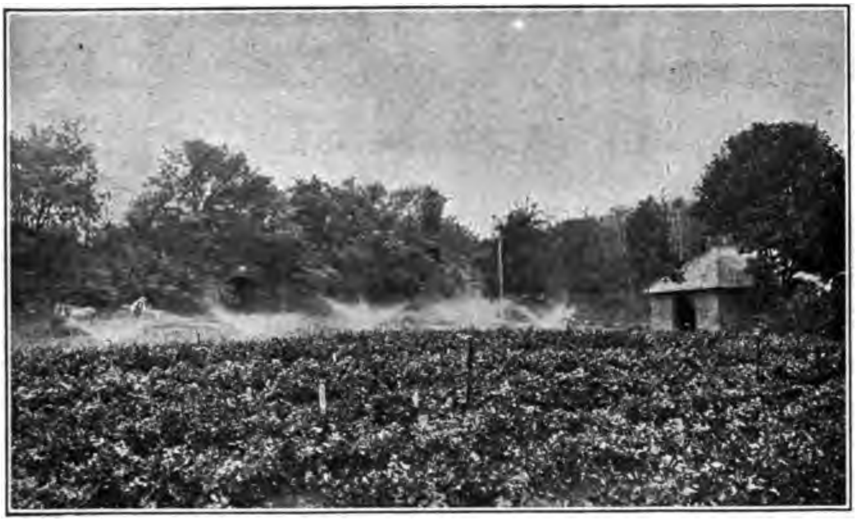


FIG. 3.—Deluge sprinklers in operation; pump house shown on the right.

Sprinkler systems.—Some growers have adopted what is known as the deluge-sprinkler system. By this method lines of pipe are laid on the surface 16 or 18 feet apart, having upright pipes about 3 feet high every 18 or 20 feet along their length. At the top of each upright is placed a distributer, known as a deluge sprinkler, which will spread the water very evenly over the entire intervening surface (fig. 3). This system has its disadvantages, as it is costly to install; the lines of pipes are in the way of cultivation, and must be removed at the end of each season and replaced at the beginning of the following year; and the expense of pumping is considerable, since the water must be driven through the pipes under a pressure of at least 60 pounds to the square inch in order to secure the best results. An 8 or 10 horsepower pump, with a 4-inch suction and a 3-inch discharge, is required to operate 16 of these sprinklers at one time; but these will thoroughly soak an area of about 20 square rods every fifteen minutes, or 1 acre every two hours. With the cost of fuel for a ten-hour day at $5 and the wages of two men $3, the cost for the running expense of watering 5 acres is $1.60 per acre for each watering.

There is another sprinkler system in use by which the lines of pipe are placed at intervals of 50 feet and carried upon posts 8 or 10 feet above ground. Every 3 or 4 feet along one side of this pipe there are inserted small brass nozzles having an opening of about one-eighth inch diameter, or even smaller. At one end the pipe is connected to the main supply pipe by means of a ground-joint union, which permits its being turned to either side. As a rule, the pipe is passed through round holes near the top of the posts and must turn freely throughout its length. In use the pipe is first turned so that the streams of water will be directed to one side, and as sufficient water is applied the direction of the streams is changed until finally the extreme opposite side is reached. The distance to which water can be delivered by this system depends largely upon the water pressure and direction of wind. This type of sprinkler does not deliver so large a quantity of water in a given time as the deluge system previously described, but it is not so expensive to install and will work under a lower water pressure. It also has the advantage that the pipes are not in the way of cultivation, and if properly graded they may be drained and can remain in position during the winter months.

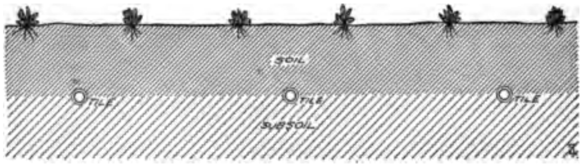


FIG. 4.—Cross section of soil, showing arrangement of tiles for subirrigation.

The subirrigation method of applying water.—The subirrigation method consists of placing perforated pipes or lines of ordinary farm drain tiles at intervals, preferably corresponding in distance to the width of the rows, at a depth of 8 or 10 inches below the surface of the soil, with surface openings every 100 feet or so to admit the water, which is run in and allowed to escape at the holes or joints of the tiles. The system works fairly well where there is an impervious subsoil, and it does not require so much water as for surface irrigation; but where the subsoil is porous the water escapes downward and is lost, and in muck or sandy soils the tiles soon become filled with silt or the roots of plants and are worthless. Celery does best under cool conditions, and this method is especially advantageous where the subsoil is suitable and a supply of cold water can be carried to the system by gravitation or drawn from a tank or from a city water supply.

A cross section showing the arrangement of tiles in the soil is shown in figure 4.

Growing celery without irrigation.—For a home supply of celery it is often possible to select a rather moist but well-drained piece of land whereon it may be grown without artificial watering. In this case the plants should be set while the atmosphere is filled with moisture, preferably between gentle showers, and the moisture afterwards retained in the soil by frequent shallow cultivation or by the application of a mulch around the plants. This method can not be followed in climates where irrigation is necessary for the production of crops, but is applicable in regions that have an ordinary rainfall during the growing season.

PLANTING IN THE OPEN GROUND.

Distances to plant.—For domestic use, where plenty of land is available, it will be found most economical to plant in single or double rows 4, 5, or 6 feet apart, with the plants 5 or 6 inches apart in the row. If the space is limited, solid beds about 5 feet wide will be found suitable, with the plants set 7 or 8 inches apart each way. By planting in rows the crop may be worked with a horse cultivator or a wheel hoe and the banking more easily done, and thus the cost of production is lessened. With the solid-bed system the work must all be done by hand.

The number of plants required to set 1 acre by various methods of planting is shown by the following table of planting distances:

Distance between rows.	Distance between plants.	Method of blanching.	Lumber required.	Number of plants to acre.
	Inches.		*Sq. feet.*	
3 feet, single	4	Boards	29,000	44,000
4 feet, double	6 by 6	.....do	21,000	41,000
5 feet, single	4	Earth		25,000
6 feet, double	6 by 6	.....do		28,000
Solid beds, one-half of land occupied	8 by 8	Self-shading		49,000

Directions for planting.—If possible, the planting should be done when the soil is rather moist and the atmospheric conditions suitable to the subsistence of the plants until the roots can again furnish sufficient moisture to supply them. The bed should be thoroughly watered a few hours before the plants are removed, and a knife or trowel should be run between the plants so that they may be lifted with a clump of earth and with most of their roots attached.

Mark off the rows with a wheel hoe, a hand hoe and line, or a marker. Place the plants in a shallow tray and set in the ground from the tray, as shown in fig. 5. When the plants are set and the soil well pressed down around them, they should be just a little below the general level of the soil, but not low enough to become covered by heavy rains. The same method should be followed when setting in beds (fig. 6), except as to marking, which should be in both directions, the plants to be set at the intersections. If no mulch is to be applied, the plants should be watered before the soil is entirely filled in around them; then, after watering, cover the wet earth with dry soil to prevent a crust being formed.

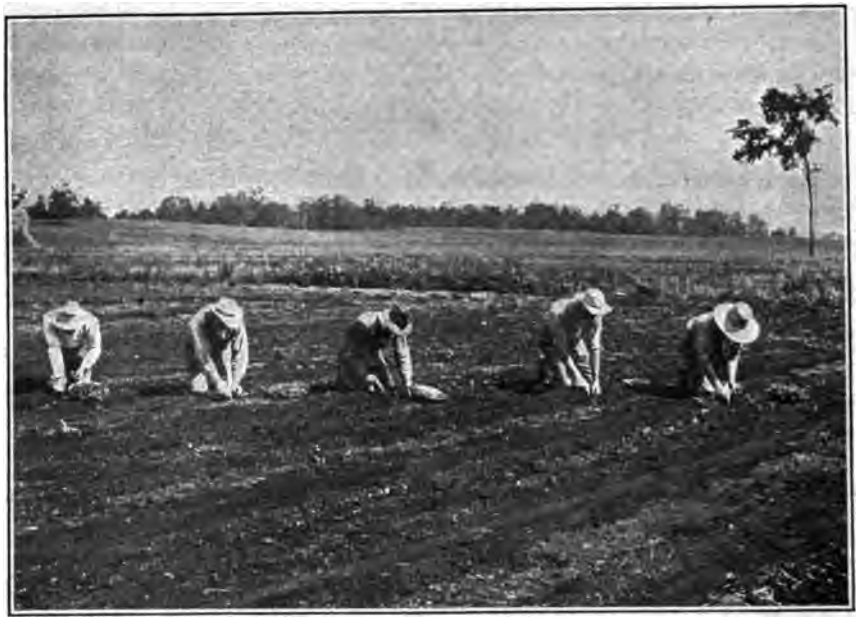


FIG. 5.—Gardeners setting celery plants in the open ground.

MULCHING.

In muck soils it will not be found necessary to mulch the ground around the plants after setting, but some kind of a covering is desirable on sandy and clay soils. As soon as the plants are in position and before any water is applied, cover the ground for a distance of 8 or 10 inches on either side with any finely divided material that will shade the top of the soil and prevent a crust being formed after watering; half-rotted manure is preferable for this, as it aids the growth by its fertilizing qualities. Good celery can be grown on clay upland with but one watering—at the time of planting—provided that plenty of mulch is applied as soon as the plants are set. The roots of celery, after it is once transplanted, run close to the surface, and the mulch will protect them from the heat of the sun. Among materials that may be used for a mulch may be mentioned pine needles, leaves of any kind, straw, cornstalks run through the cutter, clippings from the lawn, etc., none of which, however, are as good as barnyard manure.

Have the material to be used as a mulch near at hand, and as the plants are set cover the soil around them to a depth of 2 inches, bringing the mulching material up close to the plant, but being careful to allow none to get into the heart. Apply the mulch before watering, if possible.

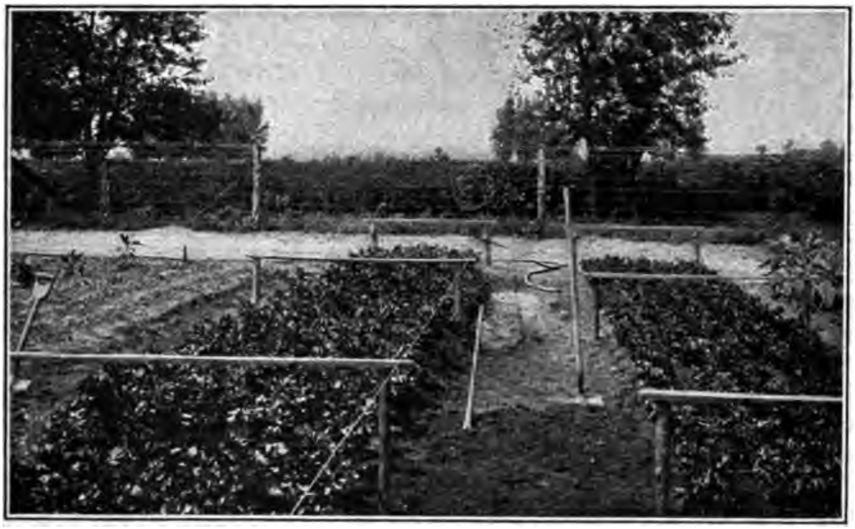


FIG. 6.—Celery growing in solid beds, showing the method of blanching by shoveling earth between the plants and also the supports used during warm weather for holding muslin shades.

CULTIVATION.

Directions for cultivating.—Where celery is planted in single rows and mulched it will only be necessary to maintain shallow cultivation between the rows, not allowing the cultivator teeth to come nearer the plants than the edge of the mulch. Where no mulch is used the cultivation may be carried a little closer to the plants, but should be very shallow, and at no time should deep cultivation be practiced, as the roots are to be found very near the surface of the soil. If a mulch is used no hand cultivation will be required, either along the side or between the plants in the row, except to pull any weeds that may spring up. Where no mulch is used it will be necessary lightly to stir the surface with a wheel hoe or iron rake, to prevent a crust being formed after each rain or watering. Keep the surface of the soil smooth and in no case allow lumps of earth to remain near the plants.

The horse cultivator shown in fig. 7 is a desirable type for working between the rows, while the wheel hoe, illustrated in figure 8, is especially useful in cultivating a small area of celery or for stirring the soil close to the plants.

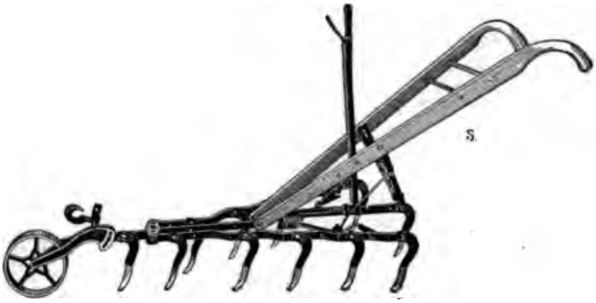


Fig. 7.—Small-tooth horse cultivator.

Maintenance of a dust mulch.—When a crop of celery is in a good growing condition the roots will be near the surface. During a dry season the roots will go deep into the soil in order to secure moisture; this can be prevented by keeping the surface of the soil well stirred to a depth of not more than 2 inches, forming a sort of dust mulch, beneath which the moisture will be drawn upward by capillary attraction and prevented from passing into the air by the presence of the loose soil on top. Under these conditions the roots will work near the moisture line, and in addition to securing the required water they will also receive more air and will be at the point in the soil where the natural preparation of plant food is taking place most rapidly; consequently a large growth and a better quality will be produced. The effects of a drought may in most cases be met by frequent shallow cultivations, supplemented by the use of water, if available.

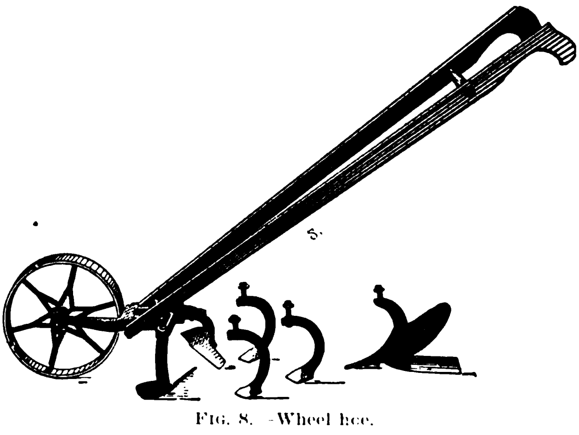


Fig. 8.—Wheel hoe.

When the water is sprinkled over the entire surface it should be done late in the day, so that the soil may, during the night, absorb the moisture and prevent a crust being formed, as would be the case were the water applied under the direct heat of the sun.

DISEASES.

"Damping."—There are several diseases which attack celery, but only three need be mentioned in this bulletin. "Damping," caused by a fungus which follows careless watering while the plants are very small, attacks the stems of the seedlings at the point where they emerge from the soil, bringing about decay. This disease may be avoided by starting the plants in trays, such as have already been described, and subwatering them by setting the trays in a shallow trough containing about 1 inch of water, allowing the water to enter through the drainage holes in the bottom of the trays. In this way the surface of the soil will remain slightly dry, while the roots of the plants receive plenty of moisture. It will always be necessary to water very carefully and to avoid extremes of drought and moisture; also to provide plenty of light and ventilation. During extremely dry weather it is best to prevent too rapid evaporation by partial shading with lath screens of thin muslin.

Celery blight.—The disease known as "blight" or "leaf-spot," which is caused by a fungus, is very prevalent and destructive. It makes its appearance at any time, usually after the plants have been set in the open field, and many acres of celery are annually destroyed as a result of its development. The first visible indication of the disease is in the form of grayish spots upon the leaves, changing to a brown or burned appearance in a day or two. If conditions continue suitable to the development of the disease, it will spread to all parts of the plant, the stems will droop, and the entire plant assume the appearance of having been scalded. The heart of the plant will continue to throw up new leaves, but, when once badly infected, it never sufficiently overcomes the disease to produce a marketable product. When this disease makes its appearance, it is already too late to attempt to eradicate it, as much of the injury has been done before the existence of blight is perceptible.

Celery blight generally appears during or immediately after a period of sultry weather, when the atmosphere is filled with moisture and the nights are warm. Bright sunshine and a clear atmosphere during the day, with cool nights, are favorable for the prevention and control of blight. Any check in growth will so weaken the plants that they are liable to be attacked by diseases. On the other hand, if the plants can be kept in a vigorous growing condition during unfavorable periods they will be in a much better condition to withstand diseases. Owing to close selection and constant inbreeding, the self-blanching varieties have become constitutionally weakened and suffer more from disease than do the hardier green sorts.

How to combat celery blight.—Under favorable conditions spraying has in many instances proved beneficial in checking blight. Bordeaux mixture[a] and ammoniacal solution of copper applied at intervals of ten days to two weeks will serve a good purpose.

Severe loss from blight is noted only where large quantities of celery are grown and handled together, and the farmer or amateur horticulturist will not as a rule be troubled if the plants are kept in a vigorous condition throughout the entire period of their growth. This may be greatly facilitated by partially shading the plants up to the time when they are set in the open field and by planting the crop on land that is rich enough to keep up a rapid and uninterrupted growth. The most satisfactory shade for the plant bed consists of a screen made of plastering laths, with openings between the laths. The size of ordinary hotbed sash is the most convenient for these screens, as they can then be placed on top of or in place of the sash.

Black-rot or heart-rot of celery.—While in the storehouse the celery is sometimes attacked by a black-rot, which, if not checked, will soon destroy the entire crop. This disease is induced by too heavy watering and by wetting the tops of the celery after it has been stored; also by keeping the storehouse too warm without sufficient ventilation. The disease is almost sure to occur where celery is stored in improperly ventilated cellars or under the benches of greenhouses, but will rarely be found in storehouses or trenches such as are described farther on in this bulletin, provided proper ventilation is maintained.

There remains no doubt that some varieties have a greater power of resisting the attacks of disease than others, and the larger growers especially should test some of the newer sorts, and secure if possible one that will combine resistance to disease with suitable market value.

INSECT ENEMIES AND THEIR CONTROL.[b]

Owing to the fact that celery has been extensively grown only during recent years, it has as yet very few insect enemies that do any considerable damage, and most of these can be controlled by very simple means.

Grasshoppers often prove destructive pests during the early part of the season, especially where the celery is planted near meadows or other habitat of these insects. Where no fowls are allowed to run, it is practicable to poison the grasshoppers by means of wheat bran to which there have been added molasses and water and enough Paris green to give the mixture a slightly green color.

---

[a] For approved formula, see Farmers' Bulletin No. 231.

[b] In case any insect is found doing serious damage to the growing celery, the grower is advised to send live specimens, together with a description of the habits of the insect, to the agricultural experiment station of his State or to the Bureau of Entomology, United States Department of Agriculture, for information regarding the best means of combating the pest.

The celery leaf tier sometimes becomes troublesome, not only because it destroys the leaves by eating them, but because it spins a web and ties the leaves together. Injury as a result of the work of this insect has been reported only from a few localities, but the insect itself is thoroughly distributed and may at any time become a troublesome pest in any celery field. As a means of controlling this insect, hand picking will generally prove effectual.

The celery caterpillar, besides being the most conspicuous of all celery insects, is perhaps the most harmful. It feeds upon the leaves, and, owing to its size and yellow color with black transverse bands, it is readily seen against the background of green foliage. This caterpillar, however, does not appear in great numbers, and hand picking is sufficient to control it. The zebra caterpillar is much smaller, but fully as striking in appearance as the insect just mentioned. It appears in greater numbers, but as a rule may be controlled by hand picking.

The tarnished plant bug has been known to injure the crop in several instances. While young this bug is very small, being only about one-twentieth of an inch in length, of a yellowish or yellowish green color, which changes to a faded yellow or dull brown when it is fully grown. It works especially where weeds abound and on crops that are somewhat neglected. As a preventive, keep the celery well cultivated and free from weeds, and do not allow any trash beneath which insects can pass the winter to lie on the ground.

METHODS OF BLANCHING.

In its original wild state the stems of celery are tough, full of woody strands, of a rank flavor, and green in color, being similar to the outside stems or trimmings of our present varieties. The object of blanching is to secure leafstalks free from woody strands, crisp and tender, and without the rank flavor found in those that are green. Of the cultivated plant we have two classes of varieties, the large-growing, or giant, and the dwarf sorts. These are again divided into those which must be blanched by excluding all the light and those which are in a measure self-blanching. Of the former the Giant Pascal variety is a type, and of the latter the Golden Self-Blanching variety is a good illustration.

Blanching is accomplished by the same general method that is employed for destroying the coloring matter in any plant tissue; that is, by excluding the light and allowing the growth to proceed in the dark. The particular method to be adopted must be determined largely by the time when the crop is to be used. If for early use or marketing, the blanching must be completed where the plants are grown; but if the celery be for winter use the blanching may take place after the crop has been removed from the field and placed in storage. In fact, it is best to blanch as little as possible before storing when the product is to be kept until late, as the keeping qualities are better while it is unblanched. When planting for early use it is necessary to choose one of the self-blanching varieties, such as may be conveniently blanched by the use of boards or other similar means.

Use of boards for blanching.—For early blanching on a small scale, such as would be employed on the farm or in the garden of the amateur horticulturist, there are several methods. One of the most common is by means of boards placed on edge along each side of the row of celery. This method is also in general use for blanching large fields of early celery. Figure 9 shows a field of celery with the boards in position. The boards used for blanching should be 1 inch thick by 12 to 14 inches wide and 12 to 16 feet long. The cheaper grades of pine will answer the purpose, but new boards are liable to impart an unpleasant flavor to the celery. The kind used by growers in Michigan, Ohio, and New York, at the rate now prevailing, costs $25 to $30 a thousand feet. In placing the boards in position, slip one edge well under the outside leaves of the plants, then bring this edge upward until in a vertical position along the

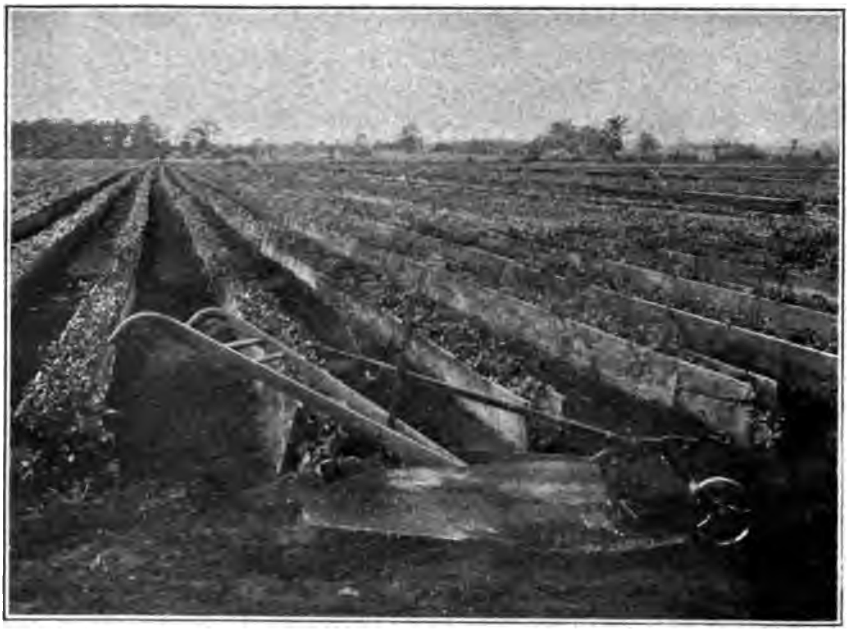


Fig. 9.—Field of celery in process of blanching by means of boards, with a celery hiller in the foreground.

row, having another board at the same time placed on the other side, so that when in position there will be as little space between the boards as the thickness of the plants will permit. These boards, when used on a small scale only, may be fastened in position by means of stakes driven in the ground, by nailing short pieces of laths across the top every 6 or 8 feet, or by placing notched sticks over the tops of the boards. Any of these methods would be too inconvenient when applied on a large scale, and a far better one is that practiced by large growers, namely, that of using double hooks, or spanners, about 6 inches long, made of heavy galvanized wire, bent somewhat in the shape of the thumb and first finger extended. These spanners are slipped over the upper edges of the boards every few feet to hold them together, and the plants are rigid enough to keep the boards in an upright position.

After the boards are in position it is a good plan to run a celery hiller, as shown in the foreground of figure 9, between the rows and to throw a little soil against the lower edges of the boards to close any openings that may result from the uneven surface of the soil.

Two or three weeks' time will be required to complete the blanching of the early varieties, and the boards must be kept in position until the crop is removed from the ground, after which they may be used again two or three times during the season. If the celery is allowed to remain in the boards too long after it has reached a marketable stage, it loses in weight and flavor and is liable to be injured or even destroyed by the attacks of blight. This is especially true during the earlier part of the season, when the weather is warm. At the end of the season the boards should be piled flat, with strips inserted at every fourth or fifth course, and the whole pile roofed over to shed off rain; treated in this manner they will last from ten to twelve years.

Use of farm drain tiles for blanching.—Perhaps the most satisfactory way of blanching early celery on a small scale is by means of ordinary farm drain tiles (fig. 10) of about 4 inches inside diameter, placed over the plants after they have become almost fully grown. To facilitate the work of placing the tiles over the plants, some of the outside leaves should be pulled away and the main part of the plant loosely tied together by means of a soft string, or, better, with what is known as paper twine, being a string made by twisting a strip of soft paper. This string will lose its strength as soon as it becomes wet, and will offer no resistance to the further growth of the plant. The presence of the tiles will cause the leaves to draw up above the top of the tiles, thereby forming a screen over the top to shut out the light from the interior. If the common, unglazed tiles are used the evaporation from their surface has a tendency to keep the plant cool during the heat of the day, and a very crisp and tender product is the result. This method of blanching is desirable also on account of its cleanliness, as celery treated in this way will need very little washing before marketing.

Use of soil for blanching.—The most common method for blanching celery on a small scale is that of banking with soil, as shown in figure 11, and it is by this means that the finest flavor can be obtained. Where the plants are set in single rows the soil can often be partially thrown up by means of a plow, or, better, by a celery hiller, as illustrated in the foreground of figure 9. There are several forms of this implement, but they all work on one principle, that of a diagonally set surface to throw up the soil. Before the plow or banking machine is used a small quantity of dirt must be placed around the plants by hand to hold them in position while the earth is being thrown around them. This may also be accomplished by tying up the plants with paper twine, as previously recommended for use in connection with tiles. Instead of tying each plant by knotting around it a short piece of string, fasten the end of the string around the first plant in a row, then pass to the second plant without cutting or breaking the string. While the outside leaves of the second plant are brought up together by the left hand, carry the string once around by allowing it to run between the thumb and finger of the right hand, and so on from plant to plant until a whole row is held up without breaking the string and by tying it at the ends only. This work is greatly facilitated by strapping to the right forearm a tin can, in which the ball of cord is placed, the inside end of the string being delivered through a hole in the bottom of the can. Another very good method

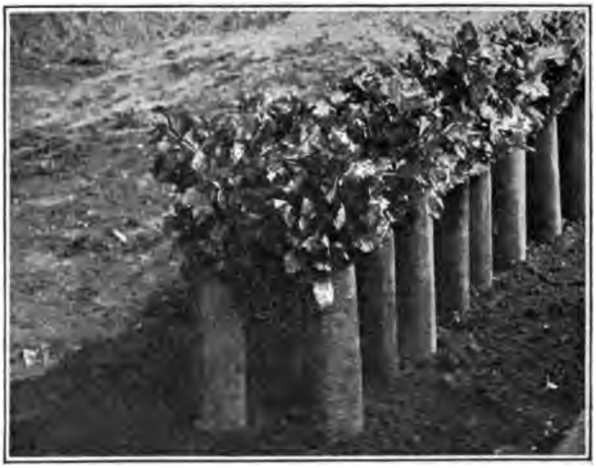


FIG. 10.—Celery in process of blanching by means of drain tiles.

of holding up the celery while the earth is being placed around it is by temporarily setting up boards, which are removed as soon as the soil is in position.

Where celery planted in solid beds is banked with earth, the entire quantity of soil required must be thrown up by hand. Under these conditions banking with soil is not profitable except on a very limited scale. Owing to the cost, blanching by banking with earth is not to be recommended, except when the crop is to be stored where grown for late fall marketing, and even then it is better, especially on muck or sandy soil, to trench that part of the crop which is to be held for a short time.

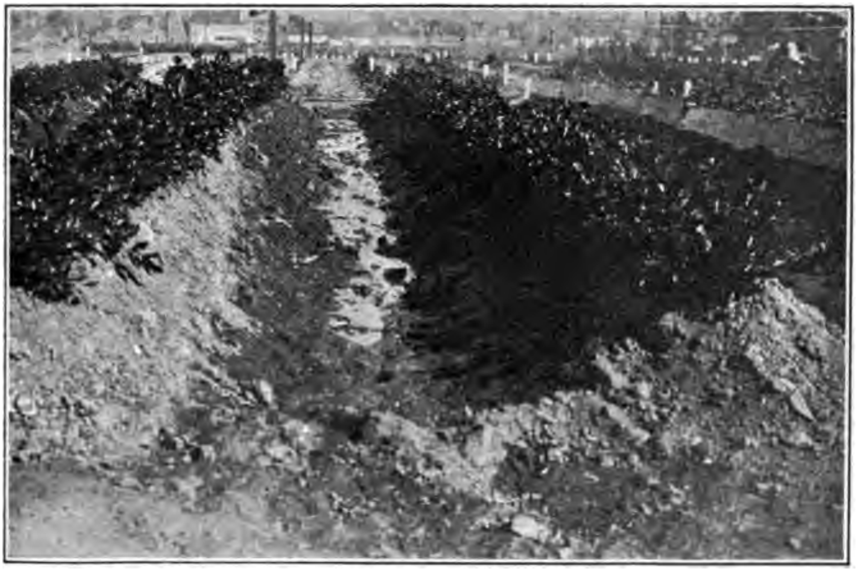


FIG. 11.—Celery in process of blanching by means of earth.

Other methods of blanching celery.—Another method of blanching is by banking with straw or leaves, but this is objectionable, as the material used generally imparts an undesirable flavor to the stems. The use of any material that is in process of decomposition will cause diseases to attack the stems.

Common brown grocery paper is sometimes employed for blanching on a small scale by wrapping it three or four times around the celery plants, then fastening it by means of rubber bands or string. This method is scarcely to be recommended, as the application of the paper is tedious and does not produce a good grade of celery.

Blanching for winter use.—As regards blanching for winter use, very little need be added to that which has been said under blanching for early use. As a rule, celery that is not blanched at all will keep longer. Since the necessary blanching will take place while the crop is in storage, it need only be mentioned that it is essential to place merely enough earth around the base of the plants while in the open ground to insure an upright and compact growth.

STORING.

Banking and covering with straw, etc.—The plan usually adopted where but a small quantity of celery is to be stored for winter use is to bank up with earth and cover the plants where grown. Place enough earth around the base of the plants to hold them in good form, and then allow them to remain without any further banking as long as there is not danger of a hard frost. When absolutely necessary to do so, the earth should be thrown up to the very tops of the plants, almost covering them, then as the weather becomes colder cover the ridge with coarse stable manure, straw, or corn fodder, held in place by means of stakes or old boards. Celery will withstand considerable frost, but its keeping qualities as well as flavor will be impaired if it is allowed to freeze. The celery can be removed from these ridges as needed, but will be found to be very inaccessible during the time when the ground is frozen hard.

Trenching.—Large growers handle the last of the crop by the method known as "trenching." The celery is partially banked with earth and allowed to remain where grown so long as there is no danger from heavy frosts. As soon as there is danger of the celery becoming frozen it is lifted and 8 or 10 rows are brought together and set with the roots bedded close together in the bottom of a shallow trench. Where blanching boards are available two parallel rows of the boards are set along the sides of the trench and the space between them is filled with celery. The earth is then banked up along the sides of the trench and a covering of boards, straw, or some similar material is put on. These trenches are usually made only 50 or 60 feet in length and are small enough to permit the removal of a whole trench at one time.

Another method of trenching is to excavate a pit to a depth of about 24 inches, 3 feet wide, and of any desired length. Thoroughly loosen the soil in the bottom or shovel in loose topsoil to form a bed in which the roots of the celery may be set. Pack this trench with fully grown plants, placing the roots close together, with considerable soil adhering to them. As the celery is placed in the trench it should be well watered and then allowed to remain open long enough for the tops to become dried off. Unless the soil is very dry at the time of storing, or extended warm weather should follow, it will not be necessary to apply any more water. Place a 12-inch board on edge along one side of the trench and bank up the surplus earth on the outside; cover the trench with a roof of boards, sash, straw on poles, or cornstalks from which the tops have been removed, placing the stalks across the pit with one end resting on the board and the other on the ground; spread over this a light covering of straw or other material which will pack close, and as the weather becomes colder increase the covering to keep out the frost. Celery stored in this manner will keep until late in the winter, and while the method is too laborious for application on a large commercial scale, it is to be recommended for the use of the farmer and small grower because of its simplicity.

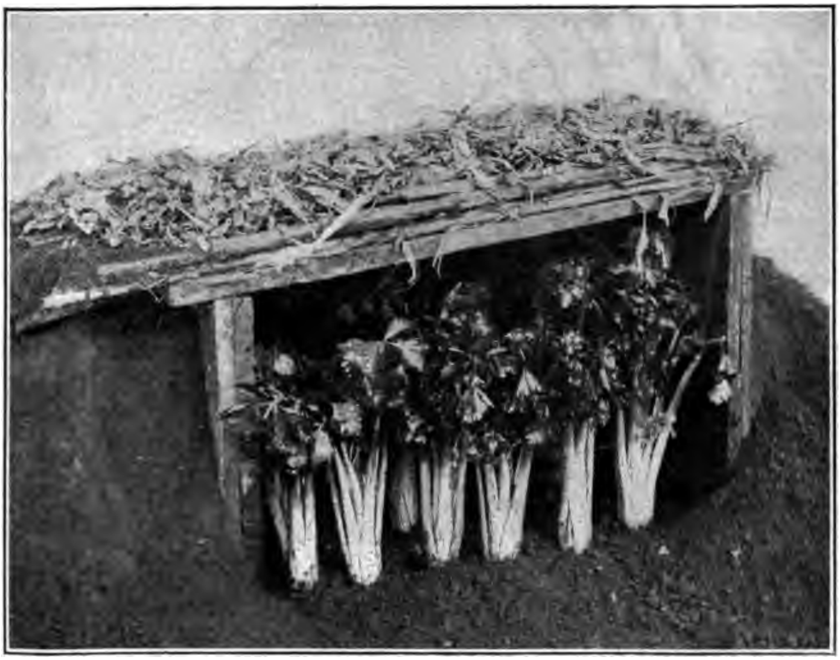


FIG. 12.—Cross section of hotbed pit used for the storage of celery on a small scale.

The unused pit of a permanent hotbed may be utilized as a storage place for celery by removing the surplus earth and substituting a covering of boards for the sash. The celery is stored in the same manner as in the trench and the bed may be covered with any material which will keep out frost. A cross section of a hotbed used for this purpose is shown in figure 12.

Storing in cellars.—Celery may be safely stored in cellars provided the temperature is kept low and plenty of ventilation maintained. The warmth and dampness of the ordinary cellar have a tendency to cause the celery to decay, but these conditions can frequently be overcome. Celery will readily absorb any odor that may be present in the atmosphere of the storage place, and care should be taken to provide sanitary conditions. When storing in a cellar, the plants should have most of their roots attached, and a bed of moist sand in which to set them should be provided.

Storing in a celery storage house.—Almost without exception the larger growers at the North have found it unprofitable to store celery for late keeping, and those who still adhere to the practice do so in order that they may control and supply a special trade. Even under special circumstances there is only a moderate profit in storing for late marketing. Where these circumstances exist the best form of storage house is a broad and long structure (fig. 13), with low walls and even-span roof coming almost to the ground at the sides. The roof should be of heavy planks, with one end resting on top of the wall and the other on a ridge pole supported by a line of posts through the center. The cracks between the roof planks may be battened with old celery blanching boards and the whole covered to a depth of 4 inches with earth, and sodded over or double-roofed to keep out frost. The ends of the house should be built double, with a dead-air space between, or consist of a heavy wall, and there should be a large door in each end. The dirt floor of the house should have a covering of 3 or 4 inches of loose sand or fine earth in which to pack the roots of the celery. It is desirable to have the storehouse subdivided lengthwise into beds about 6 or 8 feet wide by means of 6-inch boards raised 3 or 4 inches from the ground and fastened to stakes. These partitions increase the circulation of air through the celery and tend to keep the plants in good position.

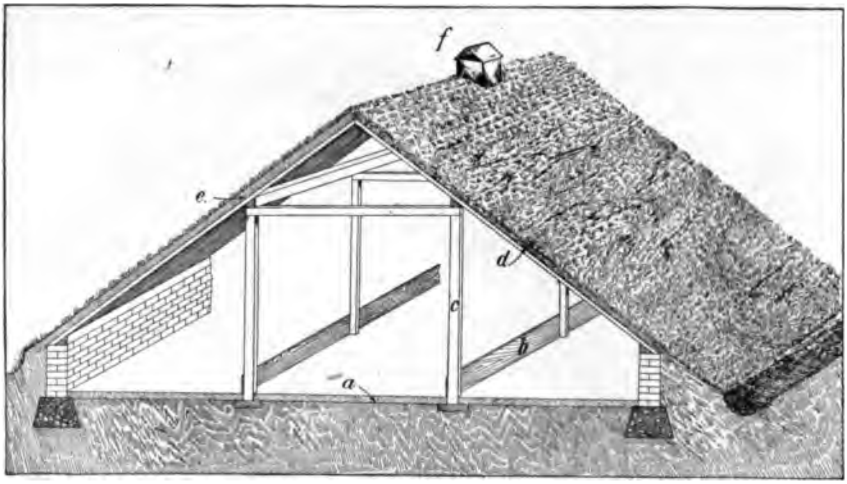


Fig. 13.—Cross section of celery storage house—width 24 feet, height of side walls 2 feet, and height in center to ridge 11 feet; *a*, bed of sand on earth floor; *b*, division boards through house; *c*, posts supporting roof; *d*, roof planks; *e*, sod, straw, or manure for frost-proofing on roof; *f*, ventilator.

Digging, handling, and putting away celery.—Where any considerable quantity of celery is to be stored, everything should be in readiness beforehand so that the crop may be brought in quickly. In the field the celery should be loosened as required, so that it may be easily pulled up by hand; for any area less than 4 or 5 acres this work can be done with spades, but on a larger scale a special implement for digging should be used. The digger most commonly employed consists of a steel cutter 5 or 6 inches in width and one-half inch thick, bent upward at the ends and sharpened on the front edge, mounted beneath and between two wheels to which a tongue is attached. The blade must be so arranged that it can be adjusted to any depth. The digger is drawn by two horses, and one row can be loosened as fast as the team will walk.

If the celery is not too tender, the handling from the field to the storehouse may be accomplished without the use of boxes; otherwise a number of boxes should be provided, each 12 by 12 by 26 or 28 inches in size, constructed of inch lumber for the ends and half-inch boards for the sides and bottom. A wagon with low, broad-tire wheels will be found convenient for the transfer. If boxes are not used, the celery should be gathered up in armfuls and piled upon the wagon. If boxes are employed, one set may be filled while the wagon is at the storehouse unloading. In using boxes the celery should be placed with the roots in the bottom. The celery should be loosened only as required for removal to the storehouse, as a short exposure to the sun after the roots have been disturbed is very injurious and detracts from its keeping qualities.

Upon reaching the storehouse the celery is taken from the wagon and laid in piles near where it is to be stored, or, if in boxes, they can be set close at hand. Beginning at the end of one of the divisions, a small furrow is opened in the soil by means of a spade, the celery is stood along in this furrow, and the soil filled in around the roots. The soil should be rather moist at the time the celery is stored, and it may be necessary to moisten it a little from time to time by inserting a hose between the plants and pouring water around the roots, but the tops should never be wet after entering the storehouse. After the storehouse is filled constant ventilation should be maintained by means of openings near the ridge, and the temperature should be kept as low as possible; care should be taken, however, that the celery does not become frozen, although a temperature that will often show a trace of frost will not injure it.

MARKETING.

During the early part of the season, or until the time for heavy frosts, the packing will be done entirely from the rows where the crop is grown, later from the trenches, and afterwards from the storehouse.

Preparing celery for market.—In preparing the celery for market from the rows where grown, it is not necessary to remove the entire root from the earth, but it may be cut off just below the surface of the soil by means of a stiff knife. Remove the outside leaves and trim the root evenly, pack in boxes, and load on the wagon for removal to the washing house. The blanching boards should not be removed till necessary, and the trimmed celery must not be allowed to lie exposed to the sun or wind for any length of time. It is well also to have a piece of canvas to protect the celery while it is on the wagon on the way to the washing house. In marketing from the trenches the process is practically the same as from the rows, except that the celery is already loosened from the soil and the roots can be removed more easily.

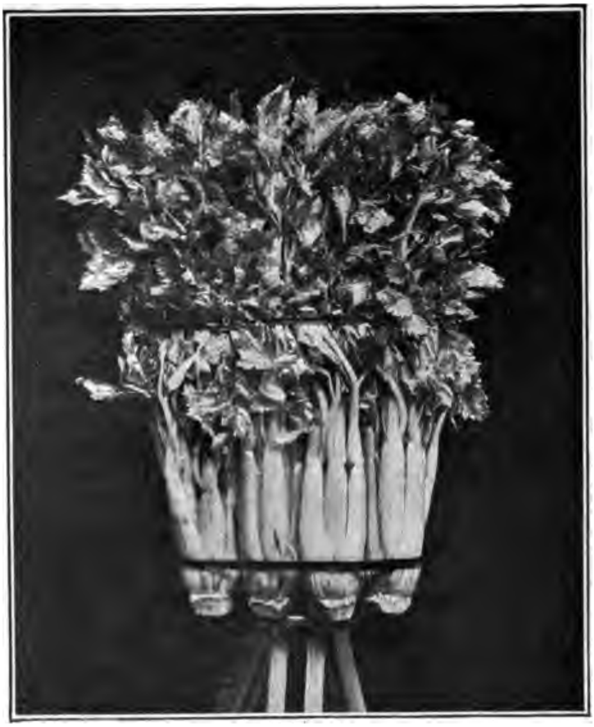


FIG. 14.—Celery trimmed, washed, and bunched ready for market.

Upon reaching the washing room the celery is placed upon a rack consisting of wooden slats over a large trough and subjected to a spray of cold water to cool it and to remove the adhering soil. After washing, it is allowed to drain; then it is tied in bunches of 12 or more plants each, according to the size, as shown in figure 14. The bunches are packed 6 in a box for first-grade celery and 8 or 9 for second or third grades. These boxes should be practically air-tight, and a lining of paper should be placed in them before packing the celery, or each bunch should be wrapped separately. The celery should be nearly dry before it is placed in the boxes, and throughout the entire handling must be kept as cool as possible.

Sanitary conditions.—Up to the present time very little attention has been given to the sanitary phase of celery growing and marketing. It is essential that the celery should be washed in pure water to prevent the transmission of disease germs. Any germ, such as that producing typhoid fever, which is found in contaminated water, is readily carried to the digestive system of the consumer, and may or may not produce an attack of the disease, according to the strength of the person to resist it. The washhouse and its surroundings should be kept clean and free from any decomposing materials. Shippers and dealers alike lose sight of the fact that the edible portion of celery is constantly being exposed to the contaminating effects of dirty wagons, unclean cars, and dusty markets. Many persons have discontinued the use of celery on account of the unclean condition in which it is served. This statement holds good for all vegetables that are served in the raw state, but it is especially applicable to celery.

Methods of shipping.—The greater part of the celery produced by the growers of Michigan, Ohio, and New York is shipped in carload lots to the eastern cities. Some growers follow the practice of washing and boxing the entire crop; others wash and tie the celery in bunches and set them in an upright position on decks in a refrigerator car. The select bunches are usually boxed and placed in the middle of the car, filling up the space between the doors. As quickly as the car is filled it is re-iced and rushed to its destination by fast freight. When celery is shipped in this manner all necessary arrangements must be completed beforehand, as any delay along the line or in handling it at destination may cause serious loss.

Several of the larger growers follow the plan of shipping in the rough; by this method only about two-thirds as many bunches can be placed in a car, but the expense of loading is greatly reduced.

The celery is lifted from the field, a few of the outer leaves pulled off, and the root trimmed roughly, after which the plants are tied in bunches of 12 to 14 each by means of common binder twine. These bunches are loaded upon wagons and hurried to the car before the celery has had time to become wilted. The first course is set root end down on the floor of the car and two decks are put in above, which will fill the car to the roof, and the space between the doors is filled in the same manner. A car loaded by this method will hold about 950 bunches, and the celery is usually in the car from three to ten days, during which time the temperature is kept down by means of ice. A more practical method of shipping in the rough is in crates similar to those used by California and Florida shippers (see fig. 15). The celery is more easily handled in such crates than in loose bunches and is less likely to beome broken and bruised. The more common form of this crate is shown in figure 16.

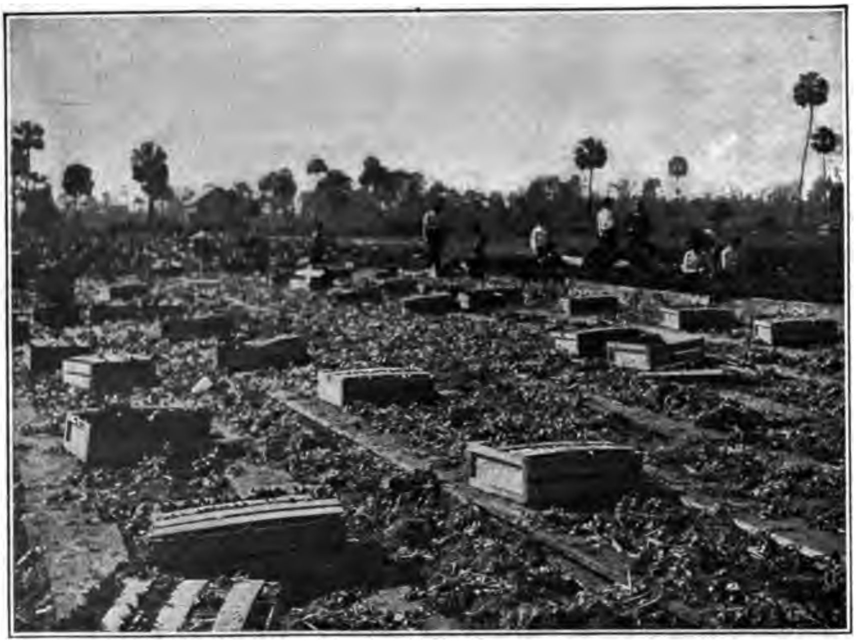


FIG. 15.—Packing celery in crates for shipping in the rough in a Florida field during February. Dimensions of the special crate shown, 11 by 20 by 24 inches.

In all cases where the crop is shipped in the rough it is necessary for the commission man to provide means for washing and rebunching the celery; or a grocer or dealer can purchase in the rough and wash the plants as needed to supply his trade. By shipping in the rough, the salable portion is protected from bruising, and the bunches look more fresh and clean when trimmed and washed but a few hours before being offered for sale.

PROFITS TO BE DERIVED FROM CELERY CULTURE.

Cost of production.—The cost of equipment for celery work should not under most circumstances be great. Assuming that the market gardener has his land in good condition and that the tools necessary for its ordinary cultivation are at his command, it will be essential only to provide a few sash under which the plants may be started, a small number of special tools, about 5,000 feet of lumber to each acre to be grown, and boxes for handling and marketing the crop, the whole outlay not to exceed $200 per acre. The annual expense of growing 1 acre of celery, including fertilizers, seed, labor, and wear and tear on equipment, will not exceed $250; provided the soil is suited to the work and the product can be placed upon the market without undue expense or labor. It would not be advisable to undertake celery culture on a large scale unless located within 2 or 3 miles of a convenient shipping point or a good local market.

Estimates of returns.—Anyone contemplating making a start in celery growing will do well to first investigate the market prospects, and unless satisfactory shipping arrangements can be made beforehand the crop should be planted only on a small scale for one or two years, until a local trade can be established. It is fair to estimate a return of 1,500 dozen from 1 acre, and this should bring 25 cents per dozen, at the lowest average estimate; this will yield a gross income of $375 to the acre, leaving a net balance of $125 to cover the interest on the investment and the profit. As a matter of fact, the growers who are making a success of celery raising—and many are doing so—receive a net profit of $100 an acre over and above the interest on the investment. On the other hand, hundreds of acres are grown annually which do not much more than pay expenses, but this is due to the fact that the soil has become exhausted and the product is consequently undersized and inferior.

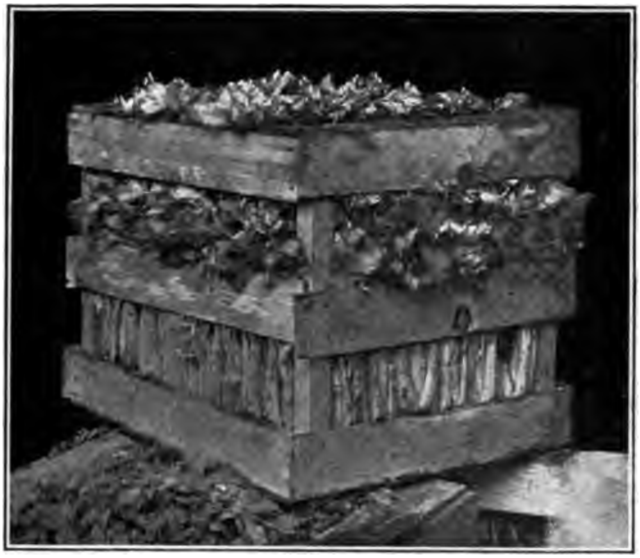


FIG. 16.—Crate of celery shipped in the rough. Style of crate employed by the California celery growers. Dimensions of crate, 24 by 24 by 20 inches.

VARIETIES OF CELERY.

Varieties for home use.—Where it is desirable to have celery for table use from midsummer until late in winter it is well to plant two or three varieties. For the earliest, plant White Plume or Golden Self-Blanching; for autumn use, Golden Self-Blanching and Pink Plume or Rose-Ribbed Paris Self-Blanching; for late keeping, Giant Pascal or Evans's Triumph.

Under the name of White Plume may be included all similar names, such as Improved White Plume, as these represent only special stocks of the same variety. This variety is one of the oldest and is still the most important with a few of the northern growers, although Golden Self-Blanching is rapidly taking its place. It grows rather slender, blanches early, and has a fine flavor.

Golden Self-Blanching is rather dwarf in its habit of growth, is stocky, and blanches readily. This variety is one of the best and is now grown almost exclusively for market purposes.

Pink Plume attains about the same size as Golden Self-Blanching, and has a rather stocky growth. The outer stems are tinted with pink color, but this is scarcely visible on the blanched and trimmed bunches. The stems are heavily ribbed, and when grown on adhesive soil they are hard to clean. It blanches well, has a fair flavor, and is a good keeper.

Giant Pascal is a large-growing variety, with broad, solid stems. It is one of the best for keeping purposes, has a good flavor, blanches clean and white, and is a desirable variety for winter use.

Evans's Triumph grows to a medium height; the stems are broad at the base, and it blanches well. It has a splendid flavor, is a good keeper, and is suitable for late winter use.

There are several other varieties of equal merit, and in making a selection a beginner should accept the assistance of his seedsman.

Varieties for market.—For market purposes it is best to grow but two or three varieties and build up a trade for a uniform product. The northern growers, for the most part, plant White Plume and Golden Self-Blanching for summer and fall marketing, and those who also make a practice of storing plant some such variety as Giant Pascal. At present there is more of Golden Self-Blanching grown than of all other varieties together.

No particular variety can be recommended for a locality until the demands of the markets are ascertained, and it would be best for any one who contemplates engaging in the business to learn what varieties are used by growers under similar conditions and to make his selection accordingly; however, it is always safe to begin with such varieties as those mentioned above.

FARMERS' BULLETINS.

following is a list of the Farmers' Bulletins available for distribution, showing
mber, title, and size in pages of each. Copies will be sent free to any address
United States on application to a Senator, Representative, or Delegate in Con-
or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have
iscontinued, being superseded by later bulletins.

e Feeding of Farm Animals. Pp. 40.
g Cholera and Swine Plague. Pp. 16.
anuts: Culture and Uses. Pp. 24.
x for Seed and Fiber. Pp. 16.
eds and How to Kill Them. Pp. 30.
ring and Other Changes in Milk. Pp. 22.
ape Diseases on the Pacific Coast. Pp. 15.
os and Silage. Pp. 30.
ch Growing for Market. Pp. 24.
ats: Composition and Cooking. Pp. 31.
tato Culture. Pp. 24.
ton Seed and Its Products. Pp. 16.
ion Culture. Pp. 30.
wls: Care and Feeding. Pp. 24.
cts About Milk. Pp. 32.
nmercial Fertilizers. Pp. 38.
igation in Humid Climates. Pp. 27.
ects Affecting the Cotton Plant. Pp. 32.
e Manuring of Cotton. Pp. 16.
eep Feeding. Pp. 24.
ndard Varieties of Chickens. Pp. 48.
e Sugar Beet. Pp. 48.
ne Common Birds. Pp. 48.
e Dairy Herd. Pp. 30.
periment Station Work—I. Pp. 30.
e Soy Bean as a Forage Crop. Pp. 24.
e Keeping. Pp. 48.
thods of Curing Tobacco. Pp. 24.
paragus Culture. Pp. 40.
rketing Farm Produce. Pp. 31.
re of Milk on the Farm. Pp. 40.
cks and Geese. Pp. 55.
periment Station Work—II. Pp. 32.
adows and Pastures. Pp. 30.
e Black Rot of the Cabbage. Pp. 22.
periment Station Work—III. Pp. 32.
ect Enemies of the Grape. Pp. 23.
entials in Beef Production. Pp. 24.
ttle Ranges of the Southwest. Pp. 32.
periment Station Work—IV. Pp. 32.
lk as Food. Pp. 39.
e Liming of Soils. Pp. 24.
periment Station Work—V. Pp. 32.
periment Station Work—VI. Pp. 27.
e Peach Twig-borer. Pp. 16.
rn Culture in the South. Pp. 24.
e Culture of Tobacco. Pp. 22.
bacco Soils. Pp. 23.
periment Station Work—VII. Pp. 32.
h as Food. Pp. 32.
irty Poisonous Plants. Pp. 32.
periment Station Work—VIII. Pp. 32.
kali Lands. Pp. 23.
tato Diseases and Treatment. Pp. 15.
periment Station Work—IX. Pp. 30.
gar as Food. Pp. 31.
od Roads for Farmers. Pp. 46.
ising Sheep for Mutton. Pp. 48.
periment Station Work—X. Pp. 32.
ggestions to Southern Farmers. Pp. 48.
ect Enemies of Shade Trees. Pp. 30.
g Raising in the South. Pp. 40.
llets. Pp. 30.
thern Forage Plants. Pp. 48.
periment Station Work—XI. Pp. 30.
tes on Frost. Pp. 24.
periment Station Work—XII. Pp. 32.
eeds of Dairy Cattle. Pp. 48.
periment Station Work—XIII. Pp. 32.
tbushes. Pp. 20.
rmers' Reading Courses. Pp. 20.
e Culture in the United States. Pp. 28.
rmer's Interest in Good Seed. Pp. 24.
ead and Bread Making. Pp. 40.
e Apple and How to Grow It. Pp. 32.
periment Station Work—XIV. Pp. 28.

115. Hop Culture in California. Pp. 28.
116. Irrigation in Fruit Growing. Pp. 48.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 30.
120. Insects Affecting Tobacco. Pp. 32.
121. Beans, Peas, and other Legumes as Food. Pp. 38.
122. Experiment Station Work—XVI. Pp. 32.
124. Experiment Station Work—XVII. Pp. 32.
125. Protection of Food Products from Injurious Temperatures. Pp. 24.
126. Practical Suggestions for Farm Buildings. Pp. 48.
127. Important Insecticides. Pp. 46.
128. Eggs and Their Uses as Food. Pp. 40.
129. Sweet Potatoes. Pp. 40.
131. Household Tests for Detection of Oleomargarine and Renovated Butter. Pp. 10.
132. Insect Enemies of Growing Wheat. Pp. 38.
133. Experiment Station Work—XVIII. Pp. 32.
134. Tree Planting in Rural School Grounds. Pp. 32.
135. Sorghum Sirup Manufacture. Pp. 40.
136. Earth Roads. Pp. 24.
137. The Angora Goat. Pp. 48.
138. Irrigation in Field and Garden. Pp. 40.
139. Emmer: A Grain for the Semiarid Regions. Pp. 16.
140. Pineapple Growing. Pp. 48.
141. Poultry Raising on the Farm. Pp. 16.
142. Principles of Nutrition and Nutritive Value of Food. Pp. 48.
143. Conformation of Beef and Dairy Cattle. Pp. 44.
144. Experiment Station Work—XIX. Pp. 32.
145. Carbon Bisulphid as an Insecticide. Pp. 28.
146. Insecticides and Fungicides. Pp. 16.
147. Winter Forage Crops for the South. Pp. 40.
149. Experiment Station Work—XX. Pp. 32.
150. Clearing New Land. Pp. 24.
151. Dairying in the South. Pp. 48.
152. Scabies in Cattle. Pp. 32.
153. Orchard Enemies in the Pacific Northwest. Pp. 39.
154. The Home Fruit Garden: Preparation and Care. Pp. 16.
155. How Insects Affect Health in Rural Districts. Pp. 19.
156. The Home Vineyard. Pp. 22.
157. The Propagation of Plants. Pp. 24.
158. How to Build Small Irrigation Ditches. Pp. 28.
159. Scab in Sheep. Pp. 48.
161. Practical Suggestions for Fruit Growers. Pp. 30.
162. Experiment Station Work—XXI. Pp. 32.
164. Rape as a Forage Crop. Pp. 16.
165. Silkworm Culture. Pp. 32.
166. Cheese Making on the Farm. Pp. 16.
167. Cassava. Pp. 32.
168. Pearl Millet. Pp. 16.
169. Experiment Station Work—XXII. Pp. 32.
170. Principles of Horse Feeding. Pp. 44.
172. Scale Insects and Mites on Citrus Trees. Pp. 43.
173. Primer of Forestry. Pp. 48.
174. Broom Corn. Pp. 30.
175. Home Manufacture and Use of Unfermented Grape Juice. Pp. 16.
176. Cranberry Culture. Pp. 20.
177. Squab Raising. Pp. 32.
178. Insects Injurious in Cranberry Culture. Pp. 32.
179. Horseshoeing. Pp. 30.
181. Pruning. Pp. 39.
182. Poultry as Food. Pp. 40.

183. Meat on the Farm: Butchering, Curing, and Keeping. Pp. 37.
184. Marketing Live Stock. Pp. 40.
185. Beautifying the Home Grounds. Pp. 24.
186. Experiment Station Work—XXIII. Pp. 32.
187. Drainage of Farm Lands. Pp. 38.
188. Weeds Used in Medicine. Pp. 45.
190. Experiment Station Work—XXIV. Pp. 32.
192. Barnyard Manure. Pp. 32.
193. Experiment Station Work—XXV. Pp. 32.
194. Alfalfa Seed. Pp. 14.
195. Annual Flowering Plants. Pp. 48.
196. Usefulness of the American Toad. Pp. 16.
197. Importation of Game Birds and Eggs for Propagation. Pp. 30.
198. Strawberries. Pp. 24.
199. Corn Growing. Pp. 32.
200. Turkeys. Pp. 40.
201. Cream Separator on Western Farms. Pp. 23.
202. Experiment Station Work—XXVI. Pp. 32.
203. Canned Fruits, Preserves, and Jellies. Pp. 32.
204. The Cultivation of Mushrooms. Pp. 24.
205. Pig Management. Pp. 40.
206. Milk Fever and Its Treatment. Pp. 16.
208. Varieties of Fruits Recommended for Planting. Pp. 48.
209. Controlling the Boll Weevil in Cotton Seed and at Ginneries. Pp. 32.
210. Experiment Station Work—XXVII. Pp. 32.
211. The Use of Paris Green in Controlling the Cotton Boll Weevil. Pp. 23.
213. Raspberries. Pp. 38.
215. Alfalfa Growing. Pp. 40.
216. The Control of the Boll Weevil. Pp. 32.
217. Essential Steps in Securing an Early Crop of Cotton. Pp. 16.
218. The School Garden. Pp. 40.
219. Lessons from the Grain Rust Epidemic of 1904. Pp. 24.
220. Tomatoes. Pp. 32.
221. Fungous Diseases of the Cranberry. Pp. 16.
222. Experiment Station Work—XXVIII. Pp. 32.
223. Miscellaneous Cotton Insects in Texas. Pp. 24.
224. Canadian Field Peas. Pp. 16.
225. Experiment Station Work—XXIX. Pp. 32.
226. Relation of Coyotes to Stock Raising in the West. Pp. 24.
227. Experiment Station Work—XXX. Pp. 32.
228. Forest Planting and Farm Management. Pp. 22.
229. The Production of Good Seed Corn. Pp. 24.
231. Spraying for Cucumber and Melon Diseases. Pp. 24.
232. Okra: Its Culture and Uses. Pp. 16.
233. Experiment Station Work—XXXI. Pp. 32.
234. The Guinea Fowl. Pp. 24.
235. Preparation of Cement Concrete. Pp. 32.
236. Incubation and Incubators. Pp. 32.
237. Experiment Station Work—XXXII. Pp. 32.
238. Citrus Fruit Growing in the Gulf States. Pp. 48.
239. The Corrosion of Fence Wire. Pp. 32.
240. Inoculation of Legumes. Pp. 8.
241. Butter Making on the Farm. Pp. 32.
242. An Example of Model Farming. Pp. 16.
243. Fungicides and their Use in Preventing Diseases of Fruits. Pp. 32.
244. Experiment Station Work—XXXIII. Pp. 32.
245. Renovation of Worn-out Soils. Pp. 16.
246. Saccharine Sorghums for Forage. Pp. 37.
247. The Control of the Codling Moth and Apple Scab. Pp. 21.
248. The Lawn. Pp. 20.
249. Cereal Breakfast Foods. Pp. 36.
250. The Prevention of Wheat Smut and Loose Smut of Oats. Pp. 16.
251. Experiment Station Work—XXXIV. Pp. 32.
252. Maple Sugar and Sirup. Pp. 36.
253. The Germination of Seed Corn. Pp. 16.
254. Cucumbers. Pp. 30.
255. The Home Vegetable Garden. Pp. 47.
256. Preparation of Vegetables for the Table. Pp. 48.
257. Soil Fertility. Pp. 39.
258. Texas or Tick Fever and Its Prevention. Pp. 45.
259. Experiment Station Work—XXXV. Pp. 32.
260. Seed of Red Clover and Its Impurities. Pp. 24.
261. The Cattle Tick. Pp. 22.
262. Experiment Station Work—XXXVI. Pp. 32.
263. Practical Information for Beginners in Irrigation. Pp. 40.
264. The Brown-tail Moth and How to Control It. Pp. 22.
265. Game Laws for 1906. Pp. 54.
266. Management of Soils to Conserve Moisture. Pp. 30.
267. Experiment Station Work—XXXVII. Pp. 32.
268. Industrial Alcohol: Sources and Manufacture. Pp. 45.
269. Industrial Alcohol: Uses and Statitises. Pp. 29.
270. Modern Conveniences for the Farm Home. Pp. 48.
271. Forage Crop Practices in Western Oregon and Western Washington. Pp. 39.
272. A Successful Hog and Seed-Corn Farm. Pp. 16.
273. Experiment Station Work—XXXVIII. Pp. 32.
274. Flax Culture. Pp. 36.
275. The Gypsy Moth and How to Control It.
276. Experiment Station Work—XXXIX. Pp. 32.
277. The Use of Alcohol and Gasoline in Farm Engines. Pp. 40.
278. Leguminous Crops for Green Manuring. (In press.)
279. A Method of Eradicating Johnson Grass. (In press.)
280. A Profitable Tenant Dairy Farm. (In press.)
281. Experiment Station Work—XL. Pp. 32.
282. Celery. Pp. 36.
283. Spraying for Apple Diseases and the Codling Moth in the Ozarks. (In press.)
284. Insect and Fungous Enemies of the Grape East of the Rocky Mountains. (In press.)
285. The Advantage of Planting Heavy Cotton Seed. (In press.)
286. Comparative Value of Whole Cotton Seed and Cotton-Seed Meal in Fertilizing Cotton. (In press.)
287. Poultry Management. (In press.)
288. Nonsaccharine Sorghums. (In press.)
289. Beans. (In press.)

O

Issued April 29, 1907.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 283.

SPRAYING FOR APPLE DISEASES AND THE CODLING MOTH IN THE OZARKS.

BY
W. M. SCOTT,
OF THE BUREAU OF PLANT INDUSTRY,
AND
A. L. QUAINTANCE,
OF THE BUREAU OF ENTOMOLOGY.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
Washington, D. C., January 26, 1907.

SIR: We have the honor to transmit herewith the manuscript of a bulletin entitled "Spraying for Apple Diseases and the Codling Moth in the Ozarks," by W. M. Scott, of the Bureau of Plant Industry, and A. L. Quaintance, of the Bureau of Entomology. We recommend that this be published as a Farmers' Bulletin. The work was conducted under the joint direction of our two Bureaus and has resulted in a remarkably successful demonstration of methods of controlling a number of the most serious fungous and insect pests affecting the orchards of this important fruit region.

The accompanying illustrations are necessary to a clear understanding of the text.

Respectfully,

B. T. GALLOWAY,
Chief, Bureau of Plant Industry.
L. O. HOWARD,
Chief, Bureau of Entomology.

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

Page.

Introduction 5

Scope of the work 6

Orchard conditions in the Ozarks 6

Plan of work 7

Bitter-rot 7

  Injury 7

  Description 8

  The cause 9

    Canker 9

  Climatic influences 9

  Demonstration spraying for bitter-rot in Arkansas 10

    The treatment 10

    The results 10

    Cost of treatments 13

  Recommendations 14

Apple blotch 14

  Occurrence 14

  Destructiveness 15

  Description 15

  Period of infection 16

  The cause 16

  Demonstration spraying for apple blotch in Arkansas 17

    The treatment 17

    The results 17

  Recommendations 18

Leaf-spot diseases 18

  The cause 19

  Results of treatment 19

  Recommendations 20

Apple scab 20

  Injury 20

  Description 20

  The cause 21

  Results of treatment 22

  Recommendations 23

The codling moth 23

  Character of injury 23

  Description and life history 24

    How the insect passes the winter 24

    The moth 25

    The egg 25

    The larva 26

    The pupa 26

  Generations of the insect 27

B. P. I.—258.

SPRAYING FOR APPLE DISEASES AND THE CODLING MOTH IN THE OZARKS.

INTRODUCTION.

During the past fifteen or twenty years the Department of Agriculture and many of the State agricultural experiment stations have been devoting much time to the study of apple diseases and insects and to conducting practical experiments in their control. Much information on this subject has been accumulated and made available for the use of orchardists through publications and correspondence, and the apple-growing industry of the country has been enormously benefited thereby. The increasing losses due to insects and diseases, following their more general dissemination and an increased food supply, has rendered their control imperative in the successful growing of this fruit, and perhaps no other crop derives such a large percentage of benefit from the use of remedial and preventive measures.

Although there are many apple growers who are successfully controlling the diseases and insect pests of their crop, perhaps the majority have not availed themselves of the remedies at hand, or are not securing satisfactory results, largely owing to lack of sufficient attention to details or to imperfect use of remedies. While some benefits have followed careless spraying, the results in many cases have not appeared to warrant the necessary outlay in expense and labor, resulting in discouragement to the grower and apparent discredit to the recommendations. Indeed, some fruit growers have come to believe that the recommended measures are entirely without merit.

The treatment for the important fungous and insect troubles of the apple mostly takes the form of spraying, and, as will at once appear, great variation is possible in the comparative thoroughness with which applications may be made. Good results also depend upon the proper preparation of sprays, the efficiency of the pumps, and the time applications are made. It is seen, therefore, that several factors are involved, the neglect of any one of which may result in partial or total failure. It has therefore appeared desirable to carry the work beyond experimentation and actually demonstrate on a commercial scale to orchardists the proper use and efficiency of control measures that have been evolved from careful experiments.

Accordingly, work of this character was planned by the Bureau of Plant Industry and the Bureau of Entomology for the season of 1906 and was carried out in apple orchards in the Ozark regions of Arkansas and Missouri, in the latter State in cooperation with the Missouri State Fruit Experiment Station. Similar work was also carried out in several counties in southeastern Nebraska, in cooperation with the Nebraska Agricultural Experiment Station. In the work herein reported the writers have had the assistance of Messrs. J. B. Rorer, F. W. Faurot, and Dudley Moulton.

SCOPE OF THE WORK.

The predominating troubles in the apple orchards of the Ozark region are apple scab, bitter-rot, apple blotch, leaf-spot, and, among insects, the codling moth. A plan of treatment was formulated which should as nearly as possible give protection from all these affections, namely, the application of Bordeaux mixture and an arsenical at such times as a knowledge of the affections indicated that spraying was necessary.

This work in Arkansas was conducted in Bentonville and vicinity, in the orchards of Mr. H. W. Gipple, Capt. George T. Lincoln, and Doctor Alden. In the Gipple orchard 200 Ben Davis and 100 Winesap trees were sprayed. In the Lincoln orchard 250 trees, about equally divided among the Jonathan, Ben Davis, Gano, and Givens varieties, and in the Alden orchard 200 Ben Davis trees were treated.

In Missouri the orchard of Fassnacht Brothers, at Springfield, and that of Mr. J. E. Hansell, at Fordland, were selected. In the Springfield orchard, 75 Huntsman and 200 Ben Davis trees were used, and in the Fordland orchard 400 Jonathan, 100 Gano, and a few Ben Davis trees were treated.

ORCHARD CONDITIONS IN THE OZARKS.

The growing of apples in the Ozarks has within comparatively recent years become a very important industry, and in that region are to be found some of the largest apple orchards of the country, in some instances covering from 500 to 1,000 acres. As a rule, however, the orchards are much smaller, ranging from 40 to 100 acres. The principal commercial varieties grown are Ben Davis, Gano, Jonathan, and Winesap, the Ben Davis and Gano varieties predominating. Trees are generally planted about 30 feet apart and come into bearing early, usually in from six to eight years. Growth is fairly vigorous, but trees do not as a rule reach large size, in part due to their early bearing. Many orchards have not had adequate cultivation, but have been permitted to grow up in shrubs, weeds, and briers. The effect of this neglect was generally apparent during 1906, the crops in neglected orchards being very light or there being no crop, whereas in well-cared-for orchards the yield has invariably been good.

As a rule, sufficient attention has not been given to the control of diseases and insects, and under such conditions these have become quite abundant and destructive. While numerous orchardists have supplied themselves with spraying outfits and have sprayed their trees, many very soon abandoned the practice, not having secured satisfactory results. The principal difficulty appears to have been lack of information concerning the troubles to be controlled and failure to comprehend what constitutes thorough spraying.

PLAN OF WORK.

A plan of treatment was adopted which called for sprayings with Bordeaux mixture having an arsenical added, except in the first treatment, as follows:

First application, when cluster buds opened, but prior to blooming.
Second application, as petals fell.
Third application, seven days later.
Fourth application, thirty days after petals fell.
Fifth application, June 25.
Sixth application, July 17.
Seventh application, August 11.

Specifically these treatments were designed to control the apple scab, codling moth, leaf-spot, apple blotch, and bitter-rot, all of which affections are quite destructive in Ozark orchards.

The early treatments were for the apple scab and the first generation of the codling moth. The later treatments, beginning with June 25, were for bitter-rot, apple blotch, leaf-spot, and the second brood of codling moth.

In practice it was not found possible to make the applications entirely as planned, but the scheme was approximately carried out, as will be detailed in the consideration of the respective affections.

BITTER-ROT.[a]

INJURY.

Bitter-rot is a fungous disease of the apple, which causes decay of both green and ripe fruit, rendering it unfit for market. It was reported as seriously destructive in Illinois as early as 1869, and with the increased development of the apple industry since that date it has appeared at irregular intervals with increasing severity in various sections of the more southern parts of the apple belt. In recent years the losses from this malady have been specially severe, amounting during some seasons to several millions of dollars. The fact that it may suddenly attack and destroy the entire crop of an orchard as the fruit approaches maturity has brought about a general dread or the trouble, and has caused a depreciation in the value of orchards in infested regions.

---

[a] For a more extended account of this disease and successful experiments in its control, see Bul. 93 of the Bureau of Plant Industry, U. S. Dept. of Agriculture, by W. M. Scott.

DESCRIPTION.

The disease first appears on the fruit as very minute yellowish-brown spots, frequently surrounded by purplish or reddish areas. These spots, which are circular in outline, gradually enlarge, assume a dark brown color, and, owing to a shrinking of the invaded tissue, become more or less depressed. By the time the spots reach one-fourth to one-half inch in diameter, minute, black, slightly raised fruiting pustules begin to appear, arranged in more or less concentric rings [illegible] appear through the skin, discharging pinkish [illegible] other rings of pustules [illegible] in evidence during [illegible] washed off by rains and are [illegible] the small black [illegible] quently [illegible] the fruit [illegible] numerous [illegible] and envelop [illegible] their individual

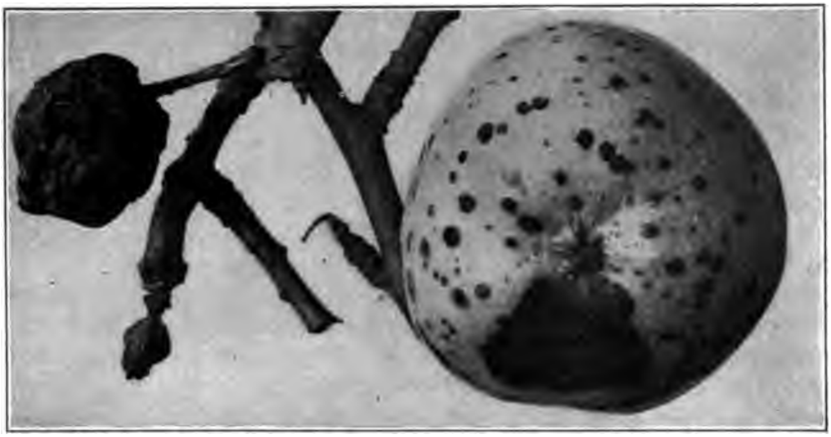


FIG. 1.—A Yellow Newtown apple affected with bitter-rot, and a mummified fruit of the preceding year's crop. (From Scott.)

outline, each producing its concentric rings of fruiting pustules. Most of the diseased fruits fall to the ground by the time or before they are half decayed, but some may become entirely rotten, dry up in a mummified condition, and hang on the tree for a year or more. This disease is illustrated in figure 1, which shows an apple affected with bitter-rot and a mummified fruit from the preceding year's crop.

THE CAUSE.

The familiar spots on the apple known as bitter-rot are caused by the growth in the tissues of the fruit of the fungus *Glomerella rufomaculans* (Berk.) Spauld. and v. Schrenk. The infection starts from very minute spores, which, falling on the surface of the apple, germinate in the presence of moisture, and the resulting tube-like growth penetrates the skin and immediately begins to branch and grow rapidly, destroying the invaded tissue and soon producing the circular, brown, sunken area already noted. The fungus penetrates toward the center of the apple about in proportion to its rate of growth as seen on the surface, and eventually the fruit, as it decays, becomes filled with the minute, almost colorless threads of the fungus.

After a time spore-bearing branches of the fungus are produced near the surface of the diseased spot, and these soon rupture the skin, giving forth pinkish masses of spores or conidia, by which the disease is principally spread. From a single diseased spot are produced many millions of spores, sufficient to furnish infection under certain conditions for an entire orchard. On the decayed apples which have fallen to the ground the perfect stage of the fungus is produced during the autumn and perhaps also the following spring. This stage serves to carry the fungus over winter and its spores are perhaps a source of infection of the new crop of apples. With the warmth and moisture of spring and early summer the fungus in mummified fruits on the trees resumes growth, producing conidia or summer spores, which serve to infect the new crop.

Canker.—The bitter-rot fungus also occurs on limbs and twigs of the apple tree, affecting the bark and cambium and producing what are known as cankers. The diseased area is sooty black, sunken, and from 1 inch to several inches in length, and the bark usually becomes cracked. Both winter and summer spores are formed in these cankers, which doubtless constitute an important source of infection of the fruit.

CLIMATIC INFLUENCES.

Bitter-rot is essentially a hot-weather disease, and its period of infection is mostly during the months of July, August, and September. Injury from it is rarely noticed before the middle of June, but with suitable weather conditions it becomes increasingly marked as the season advances. Hot, showery weather is ideal for the development of the disease. Moisture is necessary for the germination of the spores, and a high temperature favors the growth of the fungus.

DEMONSTRATION SPRAYING FOR BITTER-ROT IN ARKANSAS.

The demonstration work was done at Bentonville, Ark., and treatment for bitter-rot was included in all the demonstration spraying at that point, but only the results obtained in the orchard of Capt. George T. Lincoln will be here discussed in detail.

This orchard was not at first selected for the general demonstration work, and it was not until July 10, after considerable infection of the fruit had taken place, that spraying was begun. On July 6 Captain Lincoln called our attention to a slight outbreak of the disease on his Jonathans, and upon investigation on July 8 from 1 to 20 affected fruits were found on each of various trees of the Jonathan, Gano, and Ben Davis varieties, and on July 10 as high as 50 diseased fruits per tree were counted on the Jonathan trees. The other variety, the Givens, appeared to be free from rot at that time. Arrangements were immediately made with Captain Lincoln for spraying a block of 250 trees about equally divided among the four varieties, and leaving 6 trees of each variety untreated as checks. Some of these check trees were left together in two rows running a third of the way through the block, near the center, while the others were distributed in other portions of the block. The trees were ten years old and in good condition, having been thoroughly pruned and well cultivated, but during the past two seasons the orchard was in clover sod.

The treatment.—The entire block, excepting the check trees, was sprayed with Bordeaux mixture on July 10, July 26, and August 9, and the Givens trees, which mature their fruit some three to four weeks later than the other varieties, received an additional application on August 27. The Bordeaux mixture was composed of 5 pounds of copper sulphate and 5 pounds of lime to 50 gallons of water, to which 2 pounds of arsenate of lead were added for protection against the codling moth. The trees were thoroughly sprayed, especial care being taken to reach every apple so far as practicable. For the first two applications a good hand pump, mounted on a 100-gallon tank and equipped with two 30-feet leads of half-inch hose and double Vermorel nozzles, was used. The other applications were made with a gasoline-power sprayer, with a 200-gallon tank, three 35-feet leads of ⅜-inch hose, and triple Vermorel nozzles, a tower being employed to reach the tops of the trees.

The results.—Although the disease was well established in the orchard before treatment was begun, the results were quite good, exceeding expectations. The spread of the disease was immediately checked by the first spraying and held under control by the succeeding applications. The invisible infections that had taken place before the treatment was begun developed into rotten spots under the coating of Bordeaux mixture, and a few fresh infections took place just before the crop was picked, the mixture having been partly washed off. On the other hand, the disease continued to develop on the unsprayed trees, new infections taking place from time to time through the season, so that very little sound fruit was left on these trees at picking time. Rains occurred at frequent intervals, furnishing ample moisture for infection.

The apples from 6 sprayed trees and 3 unsprayed or check trees of each variety were classified into rotten and sound fruit, the term "sound" applying to all fruits not affected with bitter-rot. The windfalls were included, and the apples of each class were both counted and measured. The results are shown in Tables 1 to 4:

Table 1.—*Comparison of sound and bitter-rot affected fruit from sprayed and unsprayed trees of the Jonathan variety, Lincoln orchard, Bentonville, Ark., 1906. Fruit picked August 29 and 30.*

Date of spraying and tree number.	Yield.	Sound apples.	Diseased apples.	Percentage of sound fruit.
Trees sprayed July 10 and 26 and August 9:	*Bushels.*	*Number.*	*Number.*	
No. 1	15.76	1,278	144	89.87
No. 2	18.26	1,563	253	86.06
No. 3	18.76	1,526	163	90.34
No. 4	10.26	749	103	87.91
No. 5	13.76	1,394	17	98.79
No. 6	24.50	2,164	309	87.50
Nos. 1 to 6 combined	101.30	8,674	989	89.76
Trees not sprayed:				
A	5.875	3	1,276	.23
B	9.35	135	1,670	7.47
C	5.875	50	1,298	3.70
A, B, and C combined	21.10	188	4,244	4.24

Table 1 shows the results from 6 sprayed Jonathan trees, separately and combined, and 3 unsprayed trees of the same variety, separately and combined. It will be noted that the average percentage of sound fruit from the sprayed trees is 89.76, while that of the 3 unsprayed trees is 4.24, the crop from the latter being almost entirely lost. It will be remembered that the Jonathan trees were the first to become infected, as many as 50 diseased fruits having been found on some trees at the time of the first application, and perhaps others had invisible points of infection. This largely accounts for the 10 per cent of loss sustained on the sprayed trees. Indeed, it was not expected that such a high percentage of sound fruit could be obtained after the disease had gained such a foothold.

Table 2.—*Comparison of sound and bitter-rot affected fruit from sprayed and unsprayed trees of the Gano variety, Lincoln orchard, Bentonville, Ark., 1906. Fruit picked September 6.*

Date of spraying and tree number.	Yield.	Sound apples.	Diseased apples.	Percentage of sound fruit.
Trees sprayed July 10 and 23 and August 9:	*Bushels.*	*Number.*	*Number.*	
No. 1	22.50	1,877	6	99.68
No. 2	19.26	1,594	2	99.87
No. 3	13.26	1,081	24	97.82
No. 4	21.52	1,711	17	99.01
No. 5	12.25	1,791	4	99.77
No. 6	8.00	1,170	10	99.15
Nos. 1 to 6 combined	96.79	9,224	63	99.32
Trees not sprayed:				
A	17.54	841	560	60.02
B	21.76	520	1,123	31.64
C	15.52	26	1,242	2.05
A, B, and C combined	54.82	1,387	2,925	32.16

Bitter-rot was not so severe on the Gano as it was on the Jonathan trees, but the crop on some of the unsprayed trees of the former variety was scarcely worth picking. As seen in Table 2, 99.32 per cent of the crop from 6 Gano trees was free from the disease, while only 32.16 per cent of sound fruit was obtained from the 3 checks.

Table 3.—*Comparison of sound and bitter-rot affected fruit from sprayed and unsprayed trees of the Ben Davis variety, Lincoln orchard, Bentonville, Ark., 1906. Fruit picked September 17.*

Date of spraying and tree number.	Yield.	Sound apples.	Diseased apples.	Percentage of sound fruit.
Trees sprayed July 10 and 23 and August 19:	*Bushels.*	*Number.*	*Number.*	
No. 1	18.73	2,101	27	98.73
No. 2	13.58	1,793	12	99.33
No. 3	6.36	825	30	96.37
No. 4	11.34	1,524	30	98.06
No. 5	4.00	541	2	99.63
No. 6	16.51	1,906	177	91.50
Nos. 1 to 6 combined	70.52	8,690	278	96.90
Trees not sprayed:				
A	2.60	18	801	2.19
B	9.64	92	1,456	5.94
C	11.88	169	1,416	10.66
A, B, and C combined	24.12	279	3,673	7.05

In Table 3 the results from the treatment of the Ben Bavis trees are given, the 6 sprayed trees yielding an average of 96.9 per cent of sound fruit and the 3 check trees only 7.05 per cent. Practically the entire crop of the unsprayed trees was lost, while the sprayed fruit suffered very little. This result is remarkably good for three applications, and such results can not be expected except after the most thorough work.

Table 4.—*Comparison of sound and bitter-rot affected fruit from sprayed and unsprayed trees of the Givens variety, Lincoln orchard, Bentonville, Ark., 1906. Fruit picked October 8 and 12.*

Date of spraying and tree number.	Yield.	Sound apples.	Diseased apples.	Percentage of sound fruit.
Trees sprayed July 10 and 23 and August 9 and 27:	*Bushels.*	*Number.*	*Number.*	
No. 1	19.86	2,341	111	95.43
No. 2	21.52	3,102	69	97.82
No. 3	23.00	2,659	10	99.62
No. 4	16.02	1,922	8	99.58
No. 5	21.26	2,017	7	99.65
No. 6	17.82	2,271	26	98.80
Nos. 1 to 6 combined	119.48	14,312	231	98.41
Trees not sprayed:				
A	4.75	3	2,266	.10
B	6.88	212	1,518	12.25
C	3.25	295	660	30.89
A, B, and C combined	14.88	510	4,444	10.29

The Givens, being a late-maturing variety, was not picked until October 8 and 12, two weeks later than the Ben Davis and six weeks later than the Jonathan. Therefore, in order to carry the crop through the season safely it was given an additional spraying on August 27. As seen in Table 4, the results were 98.41 per cent of sound fruit from the 6 sprayed trees and 10.29 per cent of sound fruit from the 3 unsprayed trees.

The above are four examples of almost complete protection against bitter-rot by the thorough application of Bordeaux mixture, and fully corroborate the results obtained in the experiments in the control of this disease conducted in Virginia in 1905. It would appear that there is no longer a reasonable excuse for the severe losses from this disease.

Cost of treatments.—In Captain Lincoln's orchard only 400 gallons of mixture were required for one spraying of 200 trees, and the work was accomplished with four men and one team in one-half day. The 40 pounds of bluestone at 8 cents a pound cost $3.20 and the same amount of lime at one-half cent a pound cost 20 cents. The four men, at $1.25 a day each, cost for the half day $2.50, and the team cost $1 for the half day. This aggregates $6.90 for spraying 200 trees, or a little less than 3½ cents a tree for one application. This makes a total cost of 10½ cents a tree for the three applications given to the Jonathan, Gano, and Ben Davis trees, and 14 cents a tree for the four applications that the Givens variety received. This is the cost of the bitter-rot treatment alone; if the cost of the arsenate of lead used for protection against the codling moth be included, 1⅙ cents per tree for each application should be added.

It will be seen from the tables that the sprayed trees averaged upward of 4 barrels to a tree, but being only 10 years old and well pruned they were easily sprayed and the cost of treatment was less than would be required for older trees.

RECOMMENDATIONS.

Although excellent results were obtained from three sprayings in the case of the Jonathan, Gano, and Ben Davis varieties, experience elsewhere has shown that it is not always safe to rely on so small a number of applications. The work here was done just at the right time, except the late beginning on the Jonathan, and with a thoroughness that is not ordinarily secured in general orchard spraying. The first application was made dangerously late, so that only two subsequent sprayings were required to cover the infection period. In the treatment of a larger orchard, requiring a week or more to cover it, such a late beginning might prove disastrous.

It is therefore recommended that four sprayings at intervals of two to three weeks, beginning about six weeks after the petals fall, be made where bitter-rot alone is to be treated. In order to get the fruit thoroughly covered with the spray before infection takes place the second application should follow the first within two weeks, while the intervals between the subsequent applications may be extended to three weeks unless the season be unusually wet and warm. Bordeaux mixture, made of 5 pounds of bluestone and 5 pounds of lime to 50 gallons of water, seems best for this disease, but the 4–6–50 formula[a] gives satisfactory results, especially where a larger number of applications are made for the combined treatment of bitter-rot and other troubles.

APPLE BLOTCH.

OCCURRENCE.

During the past several years the Department of Agriculture has received specimens of apples affected with a fungus (*Phyllosticta* sp.) causing blotches or spots, which so disfigure the fruit as to render it unmarketable. This disease has been variously known as "Phyllosticta," "black-scab," "late-scab," "cancer," and "fruit-blotch."

The records of the Department show that apples affected with this disease have been received from Virginia, Maryland, New Jersey, Ohio, Nebraska, Kansas, Missouri, Arkansas, Oklahoma, Indian Ter[illegible]ory, and Texas. It has also been recorded from southern Illinois [illegible] hough appearing to have rather a wide distribution, [illegible] ted much [illegible] ention. This is perhaps due largely to [illegible] ocalities it has [illegible] been a serious pest [illegible] the ordinary [illegible] the orchards [illegible] the season [illegible] ples from [illegible]

[illegible] of water.

[illegible] B, fig. 1.

DESTRUCTIVENESS.

The serious nature of apple blotch became apparent during the past season in southern Missouri and northwestern Arkansas, where 50 to 90 per cent of the apple crop was destroyed by it in a large number of orchards. During the month of September an examination of a dozen orchards in Benton County, Ark., showed the following estimated percentages of the crops affected by this disease:

Number of trees and percentage of affected fruit.

	Orchard number.											
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Number of trees	800	1,000	2,000	4,000	1,000	1,500	1,500	500	500	25,000	500	1,000
Percentage of affected fruit	50	40	80	75	90	90	50	15	90	75	80	75

These orchards are located at widely separated points in the county, and the table fairly represents the conditions that obtained in unsprayed orchards throughout that section. Where the injury ran over 75 per cent of the crop no attempt was made to pick and barrel the fruit. It was usually shaken off and taken to the evaporators. Practically all of the fruit affected with this disease was unfit for barreling, but the larger percentage of it made good evaporator stock.

The season was unusually wet, which may account in part for this serious outbreak. According to the statements of a number of prominent apple growers of Arkansas, the disease has been a serious pest in that State for at least four years, but the severity of the outbreak during the past season is probably unusual.

DESCRIPTION.

The disease known as blotch first appears on the surface of the apple as a small irregular brown spot, which slowly increases in size until, after several weeks, it reaches one-fourth to one-half inch in diameter. Although the general outline of the spot is circular the margin is broken and fringed, with a radiating appearance, suggesting the name "blotch." (See fig. 2.) When the diseased area reaches about one-eighth to one-fourth inch in diameter several raised points (fruiting bodies) appear at and near the center. These points are dark brown at the apex, shading off into a light brown at the base. As the disease advances these bodies become more numerous, and although arranged somewhat in groups they are scattered rather promiscuously over the blotch. In some instances these bodies may uplift the skin of the apple in such a way as to form drab-colored blisters. The diseased area is rather superficial and slightly depressed and the epidermis becomes very hard.

Several blotches may occur on the same fruit, and in the Ozarks during the past season it was not uncommon to find 20 to 50 blotches on a single apple, covering practically the entire surface. The tissues of the invaded area being dwarfed by the action of the fungus, further growth of the apple results in a cracking of the fruit similar to that produced by the apple scab fungus. The cracks range from one-fourth to 1 inch in length and frequently extend almost to the center of the apple. In extreme cases a crack may almost encircle the apple, practically dividing it in half, and one crack may intersect another, forming a cross. Fruits only slightly affected with the disease may go through the season without developing cracks. These are more commonly developed shortly before the fruit matures, though a few may occur earlier in the season. The skin being thus broken, the fruit becomes an easy prey to other fungi and soon goes down in decay. As a rule the affected fruit drops prematurely, and the unsprayed Ben Davis trees left as checks in the demonstration blocks at Bentonville, Ark., shed 50 per cent of their crop some days before picking time.

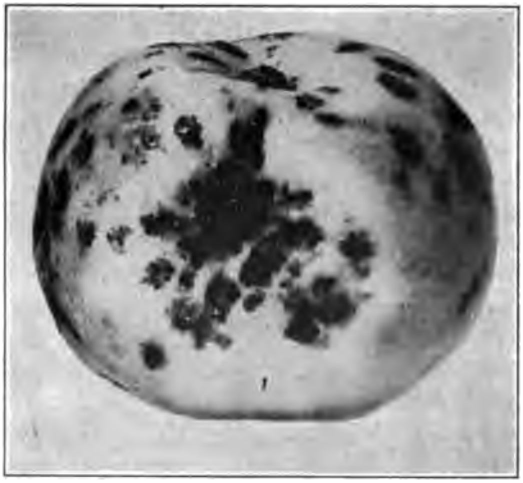


FIG. 2.—A Maiden Blush apple affected with apple blotch. (Original.)

PERIOD OF INFECTION.

Infection does not begin to take place until the fruit is nearly half grown. The blotch was first observed on the check trees June 26, and only a few affected fruits could be found on that date. On July 16 a large percentage of the Ben Davis apples was affected, and by the middle of August it was clearly seen that the crop was practically lost. It developed first on fruit on the lower branches and within the shaded portions of the tree, but finally spread to almost the entire crop.

THE CAUSE.

Apple blotch appears to be the same disease as that described from Illinois by Clinton[a] as due to an undescribed fungus, belonging to the genus *Phyllosticta*. This fungus is under investigation by Messrs. Rorer and Scott, of the Bureau of Plant Industry, who expect to report on it at the end of another season.

---

[a] University of Illinois Agric. Exp. Sta. Bul. 69, pp. 190–192, Pl. B, fig. 1.

The treatment.—As stated above, the apple blotch appeared to a disastrous extent in some of the demonstration blocks. Excellent opportunities were, therefore, afforded for observing the effect of spraying with Bordeaux mixture in the control of this disease in connection with the spraying in the Gipple orchard at Bentonville, Ark. One hundred Ben Davis trees, 18 years old, fairly vigorous and in good condition, were used, of which number 24 trees were set aside as checks and left untreated. A block of 100 Winesap trees was also used in the demonstration work, but as the apple blotch did not develop to a serious extent on this variety, only the results obtained on the Ben Davis block will be reported here.

The trees were sprayed with Bordeaux mixture on May 4 (about four days after the petals had fallen), May 8, June 12, June 26, July 17, and August 4, making six applications in all. This orchard was reached late, and the two early applications were made only four days apart in order to thoroughly poison the fruit for the codling moth before the calyx lobes closed, and for protection against apple scab. The formula of Bordeaux mixture used was 4 pounds of bluestone and 6 pounds of lime, with the addition of 2 pounds of arsenate of lead, to 50 gallons of water.

The results.—The crop was picked from September 19 to 27, and the fruit from each of the several sprayed and unsprayed trees was classified according to injury from scab, apple blotch, bitter-rot, black-rot, and the codling moth, the affected apples being counted in each case. The crop from the remaining trees, sprayed and unsprayed, was simply classified as merchantable and unmerchantable fruit, as shown later (p. 33). The windfalls were included in the counts, so that practically every apple produced by the trees was taken into account. The first count of windfalls was made on August 4 in order to get their classification before they decayed, and the fruit that fell subsequently was classified at the time the crop was harvested.

The results of the treatments in controlling the apple blotch are shown in Table 5.

TABLE 5.—*Comparison of sound fruit and fruit affected with apple blotch from 3 sprayed and 3 unsprayed Ben Davis trees, Gipple orchard, Bentonville, Ark., 1906. Fruit picked September 19 to 27.*

	Trees sprayed May 4 8, June 12, 26, July 17, and August 4.				Trees not sprayed.			
	No. 1.	No. 2.	No. 3.	Nos. 1 to 3 combined.	A.	B.	C.	A, B, and C combined.
Total bushels	17.0	18.3	19.5	54.8	14.5	5.85	3.19	23.54
Number of sound apples	2,145	2,617	2,649	7,411	872	226	72	1,170
Number of diseased apples	140	320	254	714	1,887	853	568	3,308
Percentage of sound fruit	93.87	89.1	91.25	91.21	31.60	20.94	11.25	26.12

As shown in Table 5, about 90 per cent of the crop from the sprayed trees remained free from the apple-blotch disease, while about 75 per cent of the crop of the unsprayed trees was destroyed by it. This fairly represents the conditions as they existed throughout the block, as shown by the comparative commercial yield of the sprayed and unsprayed trees given later (p. 33). It will be noted, however, that in spite of the spraying nearly 10 per cent of the crop was affected, but the diseased spots were, as a rule, very small, and in many cases scarcely noticeable. They were mainly on apples that were on low-hanging branches, well in toward the trunk and protected from the spray by the outer branches. In cases where only one side of an apple was reached by the spray, owing to some obstruction, the spots developed on the unsprayed side. This emphasizes the importance of driving the mixture into all parts of the tree in order to spray every apple thoroughly. Since the period of infection is about the same as that of bitter-rot, it appears that the same treatment is applicable to both diseases. In connection with some bitter-rot experiments conducted in the same orchard, it developed that the early applications were not necessary for the control of apple blotch. In fact, trees that were sprayed May 4, May 8, June 12, and June 27 had 46.6 per cent of the crop affected with apple blotch, showing that these applications gave only slight protection against this disease.

RECOMMENDATIONS.

Make four applications of Bordeaux mixture at intervals of two weeks, beginning about six weeks after the petals fall. This corresponds exactly with the treatment for bitter-rot, and the two diseases may, therefore, be controlled with the same applications. However, as apple blotch seems rather more difficult to control than bitter-rot, in sections where severe outbreaks occur treatment should perhaps begin a week earlier and be continued later, making five applications in all. So far as the writers know, these are the first experiments in which this disease, when occurring on the fruit, has been successfully controlled.

LEAF-SPOT DISEASES.

There are several species of fungi that attack apple leaves, producing brown, circular spots that range from mere specks to spots one-fourth of an inch in diameter and in some cases much larger, as shown in figure 3. The disease may begin to appear in the spring soon after the young leaves unfold, but the spots are usually more prominent between midsummer and the end of the season. This diseased condition causes the leaves to drop prematurely, frequently leaving the trees denuded in early autumn, six weeks or two months before the normal period of leaf fall. Trees thus deprived of their foliage cease activity, and as a result the fruit is small and not properly matured; the buds for the crop of the following year are weakened and in some cases not fully developed, and the life of the tree is materially shortened. These leaf diseases are partly responsible for the failure of the trees to produce crops and for the early decline of the orchard.

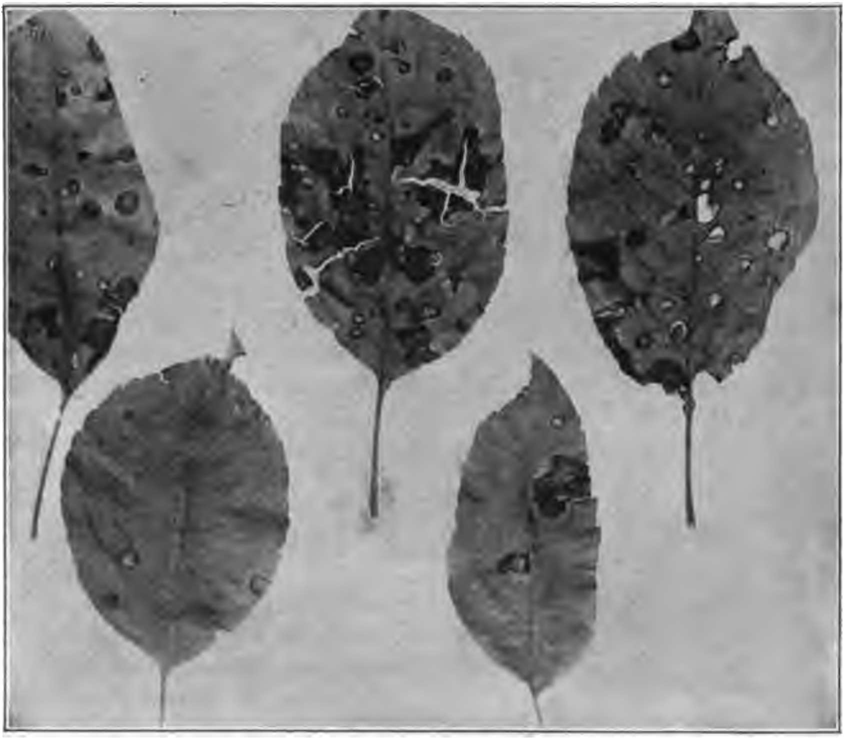


FIG. 3.—Apple leaves affected with leaf-spot diseases. (Original.)

THE CAUSE.

Leaf spots are due to several different fungi, perhaps the most prominent of which is a species of Phyllosticta. A species of Hendersonia and the ordinary black-rot fungus, *Sphæropsis malorum*, are found in connection with some of these spots and may be responsible for the injury in some cases. Other fungi are also frequently present in the dead areas, and it is not always clear which are the real parasites.

RESULTS OF TREATMENT.

One of the most striking results of spraying an apple orchard is the effect on the foliage. These leaf diseases are largely prevented by applications of Bordeaux mixture, and the foliage remains fresh and green long after unsprayed trees are defoliated. This was true of all the demonstration blocks in the Ozarks during the past season. The unsprayed trees began to shed their leaves in July and were practically defoliated by the last of August, a month before the time to pick the crop.

RECOMMENDATIONS.

The treatment recommended for bitter-rot and apple blotch will largely prevent these leaf troubles and hold the foliage in good condition until frost. It is true that some of the leaves become affected soon after they unfold in the spring, but the trouble does not usually become serious before midsummer, and the four applications of Bordeaux mixture for bitter-rot at intervals of two to three weeks, beginning about six weeks after the blossoms are shed, appear to give reasonable protection. However, the earlier applications usually necessary for the control of apple scab and the codling moth aid in the control of leaf-spot diseases, and when these are made, only one or two of the later sprayings are necessary. When it is desired to spray for leaf-spot diseases only, the first application should be made about two or three weeks after the petals have fallen, and a second about seven weeks later. These two applications, if thoroughly made, will usually hold the foliage in good condition.

APPLE SCAB.

INJURY.

The apple crop of the United States suffers a greater loss by far from the attacks of scab, caused by *Venturia inæqualis* (Cke.) Ader, than from any other fungous disease to which this fruit is subject. It often affects 50 to 75 per cent of the crop over wide areas, and is not infrequently responsible for total failures by killing the young fruits when in blossom or soon thereafter, and by rendering the fruit too unsightly for the market.

Scab has a wide distribution, being exceedingly serious in New England, the Middle Atlantic States, the Mississippi and Ohio valleys, and the Pacific Northwest. In these regions it is almost impossible to obtain crops reasonably free from scab without spraying. Indeed, so great is the damage done by this fungus and the codling moth that the percentage of strictly first-class fruit placed on the market is quite small, the great bulk of the crop, as a rule, being only second class.

DESCRIPTION.

The scabby spots that appear on the fruit are so familiar to apple growers that a description here is almost superfluous. They are circular, rough, somewhat irregular in outline, grayish or olive-green in color, becoming black when older, and range in size from mere specks to spots one-fourth to one-half inch in diameter. Two or more spots may coalesce, forming large, irregular scabby areas. The ruptured skin of the apple usually persists around the margin of the spot, leaving a light-colored ring at the border of the healthy tissue.

Young fruits affected with this disease may become pitted, one-sided, and otherwise distorted, and in severe cases the fruit becomes cracked, as shown in figure 4. The fungus may attack and destroy the blossoms and even the unopened buds; the flower stalks may become so weakened by the disease that the young fruit drops off. The disease also appears on both sides of the leaves and on the leaf-stalks in the form of smoky brown patches, which become swollen and blister-like. It often causes the leaves to curl more or less and results in the premature shedding of the foliage. The scab first appears early in the spring on the young buds and unfolding leaves, and new infections may continue to take place throughout the season.

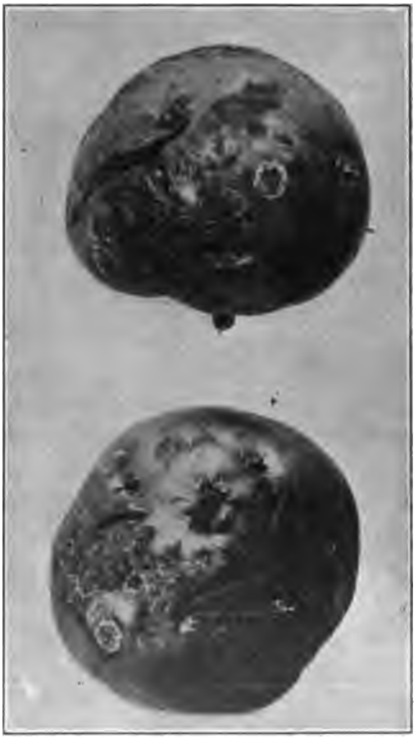


FIG. 4.—Apples badly affected with scab. (Original.)

THE CAUSE.

Apple scab is due to the presence of the fungus *Venturia inæqualis* (Cke.) Ader, which grows beneath the cuticle of the leaves and fruit, invading the superficial cells with its branching threads. In a short time the fungus gives rise to groups of small stalks, which break through the cuticle, or skin, and give forth numerous minute olive-colored spores. These spores are blown about by the wind, and it is by means of these wind-dispersed spores that the infection takes place. The fungus is carried over winter in the diseased leaves on the ground, where spores of the perfect stage are produced, which are discharged in early spring as the young leaves and fruit buds begin to open. These winter spores start the infection, which is further spread by the summer spores, soon produced by the new scab spots.

RESULTS OF TREATMENT.

The treatment for apple scab has been known for a number of years. It was worked out fully by the Bureau of Plant Industry in 1891–1893 in experiments carried on in the State of New York. Certain progressive apple growers have known that thorough applications of Bordeaux mixture just before the trees bloom, and again as soon as the petals have fallen, will largely prevent this disease.

The scab was not serious in the Ozark region during the past season, and unsprayed trees showed but slight infections. On this account the results from spraying in the demonstration orchards are not considered of sufficient importance to present here. It may be worth while, however, to give some results in controlling scab obtained in the orchard of the Morton estate at Nebraska City, Nebr., in connection with a spraying experiment conducted by the Department of Agriculture during the past season, devoted to codling moth as well as scab.

There were 13 different plots of 6 trees each and 12 checks, but only plots 1 and 2 and the checks will be here considered, as these other plots were devoted primarily to the codling moth or were planned to show the danger of omitting treatment at critical periods. Plot 1 was sprayed first when the cluster buds were open, shortly before blooming (April 25), and again as soon as the petals had fallen (May 11). Plot 2 had the same applications and a third spraying on May 17. The 5–5–50 formula of Bordeaux mixture was used for the first application, and the 4–6–50 formula with 2 pounds of arsenate of lead for the succeeding applications. The results from 3 trees of each sprayed plot and 3 untreated trees are given in Table 6:

TABLE 6.—*Comparison of sound and scabby fruit from sprayed and unsprayed winesap trees, Morton orchard, Nebraska City, Nebr., 1906. Fruit picked Oct. 20.*

Tree.	Total quantity.	Sound apples.	Diseased apples.	Percentage of sound fruit.
lot I:*a*	*Bushels.*	*Number.*	*Number.*	
No. 1 ...	22	5,157	145	97.26
No.	18	4,591	128	97.28
	13.5	3,345	33	99.02
	53.5	13,093	306	97.71
	18	4,607	46	99.01
	15	4 256	11	99.74
	14	4,057	51	98.78
	47	12,920	108	99.17
	11	971	1,949	33.25
	12	1,297	1,890	40.69
	16	1,309	2,626	33.26
	39	3,577	6,465	35.62

[illegible] petals fell.

As has been abundantly demonstrated in the past, these results again show that apple scab can be readily controlled by applications of Bordeaux mixture. It is seen in Table 6 that Plot I, which had two applications, yielded 97.71 per cent of sound fruit, and that Plot II, which received three applications, gave 99.17 per cent of sound fruit. In this case the third application was of very little additional benefit; but if the second spraying is not thoroughly done a supplemental treatment a few days later is quite important. It should be understood, however, that these results, obtained from two or three sprayings, apply only west of the Missouri River. In the more humid sections to the eastward, especially around the Great Lakes, in a wet spring 5 or 6 treatments are necessary.

RECOMMENDATIONS.

Spray with Bordeaux mixture, 5-5-50 formula, when the cluster buds are open but before blooming, and again as soon as the petals have fallen. If the second application has not been very thorough, a third should be made seven to ten days later. In case of a wet spring three sprayings are usually necessary.

THE CODLING MOTH.

The larva of the so-called codling moth (*Carpocapsa pomonella* L.) is by far the most serious of the insect pests which affect the apple. The losses due to its work equal if they do not exceed the losses from all other insect pests of this crop combined. In unsprayed orchards throughout the country from one-half to three-fourths of the crop is destroyed, entailing a loss of millions of dollars annually. A large percentage of this loss is preventable, as has been known for many years, and a large number of orchardists practically control the insect by timely and thorough work with sprays. Indeed, the codling moth is perhaps more satisfactorily controlled than most other insect pests of the apple, such as apple-tree borers, the apple maggot, the plum curculio, scale insects, and the wooly apple aphis. Notwithstanding the large amount of testimony from experimenters and practical orchardists as to the advantages of spraying, there are yet many growers who take no steps to control the pest or who secure only indifferent results from lack of knowledge of the insect itself and of the requisites for successful control work.

CHARACTER OF INJURY.

Wormy apples (see fig. 5) are familiar to all growers and consumers of this fruit, and many have seen, upon cutting open an apple, the small, pinkish larva, about three-fourths of an inch long, the cause of all the mischief. The greater part of the life of the larva is spent within the fruit, during which period it feeds freely on the substance of the apple, eating out a cavity or tunnel and pushing out from the entrance hole a considerable quantity of powdery brown frass. Most apples injured when small, as by larvæ of the first generation, drop from the trees, and these often constitute a large percentage of the so-called windfalls. Larvæ of the first generation will mostly enter the fruit at the blossom end, some, however, entering at the side, as where two fruits are in contact or where an apple is touched by a leaf. Larvæ of the second generation enter the fruit more from the side than the calyx end, and by reason of their greatly increased numbers cause the larger part of the total injury. In localities where a third or partial third brood may occur, the habits of this generation are no doubt practically identical to those of the second.

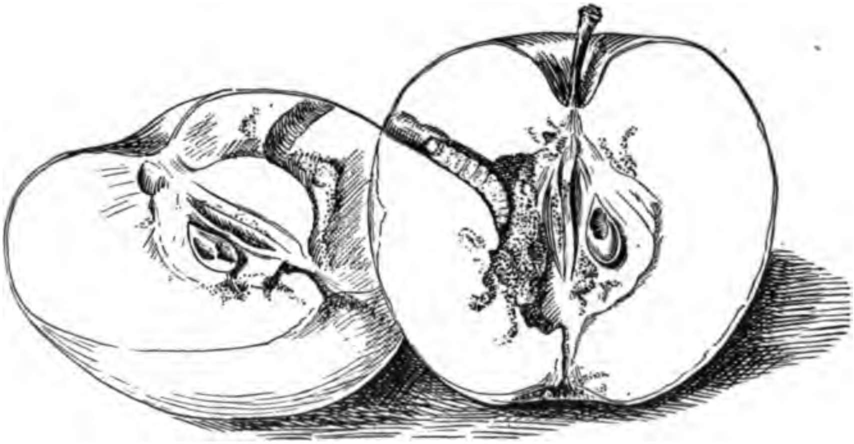


FIG. 5.—A wormy apple, showing a mature codling moth larva and its work. (Original.)

DESCRIPTION AND LIFE HISTORY.

How the insect passes the winter.—In late summer or fall larvæ seek protected places upon the trees, as holes, cracks, crotches of limbs, or under bark scales, or even underneath trash on the ground, construct tough silken cocoons, and here pass the winter in the larval condition. Large numbers of larvæ are carried to storage houses in apples in the fall, where later they spin cocoons in the boxes, bins, or barrels, or in cracks in the floor or sides of the house. In the orchard large numbers of larvæ are destroyed during winter by birds, principally woodpeckers, but in storage houses a large proportion doubtless survives, the moths from which fly to the orchards in the spring and constitute an important source of infestation.

With the coming of spring the larvæ enter the pupal stage, and later, about the period of blooming of the apple, the moths begin to appear, continuing to emerge for three or four weeks, while belated moths may not emerge until considerably later.

The moth.—The adult, or miller, (fig. 6, *a*, *f*) is rather variable in size, but the maximum wing expanse rarely exceeds three-fourths of an inch. The forewings above are of a brownish gray color, with numerous cross lines of gray. Near the tip of each wing is a conspicuous brown spot, or ocellus, in which are two irregular broken lines of a metallic coppery or golden color. The hind wings above are grayish brown, becoming darker toward the margin, which bears a delicate fringe, at the base of which is a narrow dark line. When at rest on the grayish bark of an apple tree, the color of the moth so harmonizes with its surroundings that it is not readily distinguished, and the insect in this stage is perhaps but little known to orchardists.

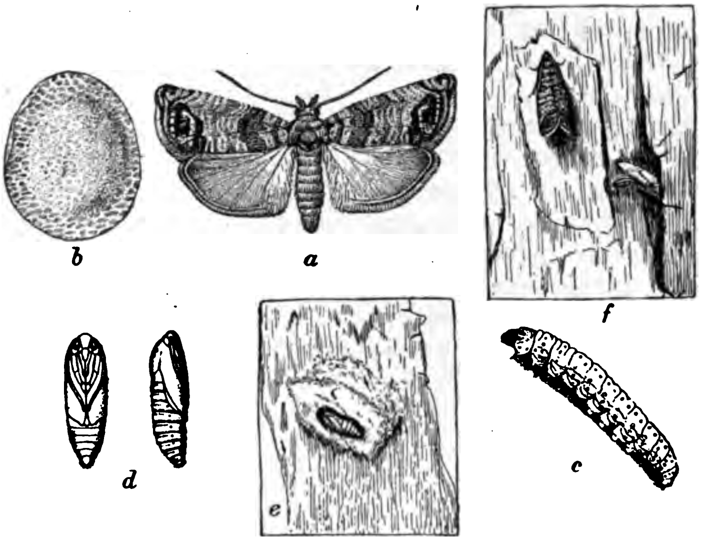


FIG. 6.—Stages of the codling moth: *a*, the moth or adult insect, slightly enlarged; *b*, the egg, greatly enlarged; *c*, the full-grown larva, slightly enlarged; *d*, the pupa, slightly enlarged; *e*, the pupa in its cocoon on the inner surface of a piece of bark, reduced about one-half; *f*, moth on bark and empty pupa skin from which it emerged, about natural size. (From Simpson.)

Shortly after emerging (fig. 6, *f*), the sexes mate and the females begin the deposition of eggs, the number for one individual, as stated in the literature regarding this insect, averaging about 50.

The egg.—The eggs are small, flat, somewhat oval in shape, of about the size of a pinhead. When recently deposited they are of a pearl-white color, but become darker with the development of the embryo, which after a few days is easily distinguished as a reddish ring within the egg. Under a lens the surface is seen to be covered with a network of ridges (fig. 6, *b*), coarser toward the edge. The eggs of the first generation of moths are deposited mainly on the leaves and twigs, comparatively few being placed on the apple, possibly on account of the fine hairs with which it may be more or less covered when small. The majority of the eggs of the second generation, however, are placed on the fruit, which by this time is much larger and presents a comparatively smooth surface. The average time required for the egg to hatch is about eleven days, the time varying considerably, however, with temperature.

The larva.—It is in the larval or "worm" stage that injury is done to the apple. The larva as it hatches from the egg is very small, from one-twentieth to one-sixteenth of an inch in length, and soon begins to search for the fruit. If hatched from eggs placed here and there on the foliage, the larvæ chew more or less into the leaf or other portions of the plant in their wandering around, and may thus be poisoned if poison be present on the plants. If the eggs have been deposited on the fruit itself the larvæ are much more likely to gain entrance to the fruit. Larvæ entering the fruit by the calyx end feed within the calyx cavity for a few days before penetrating the fruit, and hence the advantage of thoroughly spraying trees shortly after the petals have fallen and while the calyx lobes are still spread, in order to place in each calyx cavity a small particle of poison to be later eaten by the little larva as it seeks to enter the fruit.

After entering the apple the larva feeds and grows rapidly and in the course of about twenty days has become full grown. At this time the insects are about three-fourths of an inch long, and the majority of them are pinkish or flesh colored on the upper surface and whitish below. The head is brown and well developed, and there are 8 pairs of legs, the 3 pairs of true legs on the thorax and 5 pairs of prolegs on the abdomen (fig. 6, *c*).

When ready to leave the fruit the larva eats out a hole at the side, or, less usually, makes its exit by enlarging the entrance hole. If the infested apple is hanging on the tree the larva usually makes its way out to the limb and thence crawls down the branches to the trunk until a suitable place for pupation is found. If the apple has fallen before the larva has gotten its growth the latter simply crawls to a convenient place and there constructs a cocoon.

The pupa.—The full-grown larva, upon leaving the fruit and finding a protected place, constructs a whitish silken cocoon (fig. 6, *e*) within which in the course of a few days it may change to pupa or may remain in the larval condition until the following spring, as explained under the next heading. The pupa (fig. 6, *d*) is about one-half inch long, at first yellowish or brownish, but later becoming quite dark brown, and shortly before the emergence of the moth assuming a distinct bronze color. This stage varies much in length, but on the average about twenty days elapse from the spinning of the cocoon until the emergence of the moth. After emergence the moths in the course of a few days begin egg laying, the entire life cycle from egg to egg requiring, on the average, some fifty days.

GENERATIONS OF THE INSECT.

The number of generations of the codling moth in a season varies with the latitude and region. In the more Northern States, as in Maine and New York, there is but one generation each year, with often a rather light partial second, the size of the second generation varying with the season. In the upper tiers of Middle Eastern and Western States, as New Jersey, Ohio, and Iowa, the second generation will be more nearly a full one. In States of the latitude of Virginia, Kentucky, Kansas, and Colorado there will be two full generations, while in the extreme South and Southwest and portions of the West a partial third generation is thought to occur. Injury from the second brood is much greater than from the first and, unfortunately, more difficult to prevent.

As stated, moths of the first or overwintering generation will begin to emerge about the time apple trees are in bloom, continuing for some weeks, the date varying according to locality and season. The moths of the second generation may begin to appear fifty to sixty days from the blooming period, though their maximum abundance will be somewhat later. The first and second generations will overlap, so that larvæ are to be found in the fruit practically throughout the season. In the Ozarks, moths of the second generation are coming out in some numbers by about July 15, the number increasing throughout late July and early August.

DEMONSTRATION SPRAYING FOR THE CODLING MOTH.

In spraying with Bordeaux mixture for the fungous diseases of the apple previously mentioned, an arsenical was always added for the control of the codling moth. In securing results the drop apples were collected from the ground and examined as to freedom from or injury by the codling moth, and the crop from the trees at picking time was similarly graded. In some cases the fruit was simply measured; in others it was actually counted.

Results in Arkansas.—In the Gipple orchard at Bentonville four trees in the Ben Davis block sprayed for bitter-rot and apple blotch were selected for obtaining data on the effect of the treatments for the codling moth. The arsenical used was arsenate of lead at the rate of 2 pounds to 50 gallons of Bordeaux mixture, and applications were made on May 4, May 8, June 12, June 26, July 16, and August 4, making six treatments in all. The first two applications, on May 4 and May 8, immediately after the petals had fallen—perhaps the most important of all treatments—were far from satisfactory, efficient spraying apparatus not then being available. Subsequent applications, however, were quite thorough, and the trees and fruit were kept fairly well coated with the spray during the remainder of the season. The orchard under experiment, however, was joined on two sides by orchards which were not sprayed and which served as sources of reinfestation, the moths undoubtedly flying into the treated orchard from the untreated ones. Injury from the second brood of the codling moth was therefore greater than would probably have been the case had the adjacent orchards received proper treatment.

The fruit from four untreated trees in the bitter-rot check was also classified in regard to codling moth injury, to serve as a basis for comparison with the sprayed trees. The yield of sound and wormy fruit from the eight trees is detailed in Table 7.

TABLE 7.—*Comparison of sound and wormy fruit from four Ben Davis trees sprayed with Bordeaux mixture and arsenate of lead and from four unsprayed trees, Gipple orchard, Bentonville, Ark., 1906. Fruit picked September 19 to 27.*

Date of spraying and tree numbers.	Total crop.	Windfalls.			Fruit from tree.			Total number of apples.	Percentage of sound fruit.
		Wormy.	Not wormy.	Total.	Wormy.	Not wormy.	Total.		
Sprayed May 4, May 8, June 12, June 26, July 16, and Aug. 4:	*Bushels*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	
Tree 1	17	41	86	127	108	2,050	2,158	2,285	93.5
Tree 2	13.1	82	167	249	117	1,433	1,551	1,800	88.8
Tree 3	19.56	167	337	504	270	2,129	2,599	2,903	84.9
Tree 4	18.33	143	244	387	215	2,335	2,550	2,937	87.8
Trees 1 to 4 combined	67.99	433	834	1,267	710	7,947	8,858	9,925	88.4
Unsprayed:									
Check A	14.5	799	454	1,253	906	595	1,501	2,754	38.8
Check B	5.59	195	97	292	421	342	763	1,055	41.6
Check C	3.19	200	120	320	224	96	320	640	33.7
Check D	5.85	336	139	475	371	233	604	1,079	34.4
A, B, C, and D combined	29.13	1,530	810	2,340	1,922	1,266	3,188	5,528	37.5

[illegible] will be seen that the average percentage of sound fruit from the [illegible] trees [illegible] the four unsprayed trees 37.5, a [illegible] injury of 50.9 per cent.

[illegible] at Fordland, Mo., was [illegible] Mansell, in a block of trees [illegible] Jonathan, and Ben [illegible] mixture and [illegible] and Paris

Applications were made on the following dates: April 20, May 7, May 16, June 8, June 26, July 17, and August 11, making a total of seven, of which, however, only six are to be considered as in any way affecting the codling moth, the treatment on April 20 being for scab and before the trees had bloomed.

The second application was made just after the petals fell from the blossoms and the third nine days later. These two, made while the calyx lobes of the young apples were still spread, were for the purpose of filling the calyx cavities with poison, and they were also important treatments for the apple scab.

The fourth application, on June 8, was designed especially to poison the foliage and fruit to destroy the codling moth larvæ, which it was thought would be hatching in considerable numbers at about that time.

The three subsequent applications were for the control of bitter-rot, leaf-blight, and the second brood of the codling moth. The results are shown in Table 8.

TABLE 8.—*Comparison of sound and wormy fruit from Gano trees sprayed and unsprayed, Hansell orchard, Fordland, Mo., 1906.*

Plot, date of spraying, and tree number.	Total crop.	Windfalls.			Fruit from tree.			Percentage of sound fruit.
		Wormy.	Not wormy.	Total.	Wormy.	Not wormy.	Total.	
Plot 1, sprayed April 20; May 7, 16; June 8, 26; July 16; August 11:	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	
Tree 1	11.76	[a]0.017	0.5	0.51	0.25	11	11.25	97.7
Tree 2	5.81	[b].005	.25	.255	[c].055	5.5	5.555	98.9
Trees 1 and 2 combined	17.57	.022	.75	.765	.305	16.5	16.805	98.1
Plot 2, sprayed April 20; May 7, 16; June 18, 26; July 17; August 11:								
Tree 1	13.419	.044	.75	.794	.125	12.5	12.625	98.7
Tree 2	6.464	0	.42	.42	.044	6	6.044	97.7
Trees 1 and 2 combined	19.88	.044	1.17	1.21	.169	18.5	18.669	98.4
Check plot, unsprayed:								
Tree 1	5.045	.42	.125	.545	2	2.5	4.5	52.03
Tree 2	10.875	.75	.5	1.25	4.125	5.5	9.625	55.17
Trees 1 and 2 combined	15.92	1.17	.625	1.795	6.125	8	14.125	54.1

[a] 3 apples. [b] 1 apple. [c] 10 apples.

The average yield of sound fruit of the two trees of Plot 1 which received Bordeaux mixture and arsenate of lead is 98.1 per cent, and from the two trees of Plot 2, treated with Bordeaux mixture and Paris green, 98.4 per cent. The average yield of sound fruit from the two untreated trees is 54.1 per cent, there being a gain in sound fruit from the sprayed trees of 44 per cent.

Ben Davis.—In each of Plots 1 and 2 of the Gano block, and in an additional plot (Plot 3) were a few trees of the Ben Davis variety which were sprayed along with the Gano, as previously stated. Plot 3 received the same treatment as Plot 2, except that the application on June 8 was omitted. The fruit from one Ben Davis tree of each of these plots, as well as from three unsprayed Ben Davis trees, was examined and classified by counting with respect to codling moth injury, and the results are detailed in table 9.

TABLE 9.—*Comparison of sound and wormy fruit from three trees sprayed vith Bordeaux mixture and arsenicals, and from three unsprayed trees of the Ben Davis variety, Hansell orchard, Fordland, Mo., 1906.*

Date of spraying and tree number.	Total yield.	Windfalls.			Fruit from tree.			Total number of apples.	Percentage of sound fruit.
		Wormy.	Not wormy	Total.	Wormy.	Not wormy.	Total.		
Sprayed Apr. 20; May 7, 16; June 8, 26; July 17, and Aug. 11:	*Bush.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	
Tree 1	14	20	168	188	153	1,754	1,907	2,095	91.7
Tree 2	13.25	11	91	102	129	1,605	1,734	1,836	92.3
Tree 3[a]	13.75	26	52	78	206	1,562	1,768	1,846	87.4
Trees 1, 2, and 3 combined	41	57	311	368	488	4,921	5,409	5,777	90.5
Unsprayed:									
Check 1	11.75	464	38	502	1,258	383	1,641	2,143	19.6
Check 2	6.875	224	24	248	697	488	1,185	1,433	35.7
Check 3	5.50	315	89	404	564	428	992	1,396	37.0
Trees 1, 2, and 3 combined	24.125	1,003	151	1,154	2,519	1,299	3,818	4,972	29.1

[a] Treatment on June 8 omitted.

The three sprayed trees show an average percentage of sound fruit of 90.5 as against 29.1 per cent, the average percentage of sound fruit from the three unsprayed trees. This is a gain of 61.4 per cent for the treated trees.

Jonathan.—In a block of about 400 Jonathan trees used in some spraying experiments in the Hansell orchard at Fordland were three plots comprising 49 trees which received the demonstration treatment. These were sprayed with Bordeaux mixture and Paris green, 1 pound to 150 gallons, on the following dates: April 19, May 3, May 12, June 7, June 26, July 17, and August 11. The first application, April 19, for scab, was without effect in controlling the codling moth. Near each end of the block of 400 trees two adjacent rows were left untreated as checks, comprising in all 70 trees. The trees in this block are about 11 years old and small for their age. The orchard had had but little attention since 1901, and the crop of fruit was very light.

The effect of the treatments in controlling the codling moth is shown by the figures from 6 sprayed and 6 unsprayed trees presented in Table 10.

TABLE 10.—*Comparison of sound and wormy fruit from trees sprayed with Bordeaux mixture and Paris green, and from six unsprayed trees of the Jonathan variety, Hansell orchard, Fordland, Mo., 1906.*

Date of spraying and tree number.	Total yield.	Windfalls.			Fruit from tree.			Percentage of sound fruit.
		Wormy.	Not wormy.	Total.	Wormy.	Not wormy.	Total.	
Sprayed Apr. 29; May 3, 12; June 7, 26; July 17; Aug. 11:	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*
Tree 1	4.37	[a]0.02	0.25	0.27	0.10	4	4.10	97.2
Tree 2	2.24	0	.12	.12	.12	2	2.12	94.6
Tree 3	3.96	[b].01	.37	.38	.08	3.5	3.58	97.7
Tree 4	1.77	0	.25	.25	.02	1.5	1.52	98.8
Tree 5	3.27	[c].03	.37	.40	.25	2.62	2.87	91.1
Tree 6	6.14	[d].02	.37	.62	.25	5.5	5.75	95.6
Trees 1 to 6 combined	21.75	.08	1.73	2.04	.82	19.12	19.94	95.8
Unsprayed:								
Tree 1	4.62	.25	.87	1.12	1.5	2	3.5	62.1
Tree 2	.99	.12	.12	.24	.25	.5	.75	62.6
Tree 3	4.48	.62	.37	.99	1.12	2.37	3.49	61.1
Tree 4	4.62	.5	.25	.75	.62	3.25	3.87	75.7
Tree 5	2.86	.62	.12	.74	.62	1.5	2.12	56.6
Tree 6	4.25	1	.25	1.25	.75	2.25	3	58.8
Trees 1 to 6 combined	21.82	3.11	1.98	5.09	4.86	11.87	16.73	63.4

[a] 5 apples. [b] 3 apples. [c] 8 apples. [d] 6 apples.

It will be seen that the average yield of fruit free from codling moth injury from the 6 sprayed trees was 95.8 per cent as against 63.4 per cent of uninjured fruit from the 6 unsprayed trees, being a gain of 32.4 per cent.

It will have been noticed that in the work in Fordland, Mo., the percentage of codling moth injury to fruit from the treated trees was appreciably less than in the work at Bentonville, Ark. As explained in regard to the treated orchard at the latter place, this was bordered on two sides by large orchards which received no treatment during the season and which without doubt served as sources of reinfestation for the treated trees. The orchard at Fordland, on the other hand, was isolated, except for one orchard bordering it on the north, which received treatment for the codling moth.

The codling moth is best controlled when all of the orchards of a neighborhood are sprayed, and uniformity in this particular on the part of orchardists should be secured if possible.

RECOMMENDATIONS.

The first treatment for the codling moth should be made immediately after the blossoms fall. In this application the aim should be to place, as nearly as possible, a particle of the poisoned spray in the calyx cavity of every apple. At this time the little apples are mostly upright on the stems, and more effective work may be done by spraying from above, directing the spray downward. Long extension rods are indispensable, and for this application an elbow fitting between the end of the rod and nozzle to better deflect the spray may often be used with advantage, or the chamber portion of the nozzle may be turned so that the spray will be directed at a right angle to the axis of the extension rod. One man at least, who should give special attention to treating the higher parts of the trees, should be on an elevated platform rigged upon the spray wagon. This is without doubt the most important of all of the applications for the codling moth, and some growers find it profitable to respray the trees at once after the first application has been finished and before the calyx lobes close, to further insure that the calyx end of each apple shall contain a particle of poison.

The second application for the codling moth should be made about three or four weeks from the dropping of the blossoms. The eggs of the first brood are hatching about this time in maximum numbers, and as they are mostly deposited on the foliage and twigs the resulting larvæ will feed more or less on these parts before gaining entrance to the fruit. Thorough spraying of foliage and fruit at this time will undoubtedly destroy many of these larvæ. If the first and second treatments have been thoroughly made, subsequent treatments are sometimes not necessary, especially if there is no danger of reinfestation from outside unsprayed orchards.

The first and second treatments may always be combined with the applications of Bordeaux mixture for apple scab. Where spraying with Bordeaux mixture is done for leaf-spot diseases, apple blotch, or bitter-rot, arsenicals should always be added for the second brood of the codling moth, and where injury from the first brood has not been satisfactorily prevented it will pay to spray for the second brood of the moth, irrespective of other considerations.

The third treatment for the codling moth (first treatment for second brood) should be made in ten weeks from the falling of the blossoms, and a fourth application should be given two or three weeks later

COMMERCIAL RESULTS.

RESULTS IN ARKANSAS.

[illegible] the effect of the treatments in controlling [illegible]th, as detailed in the fore- [illegible] larger number of trees in [illegible]fied into marketable [illegible] damage from the [illegible] fruit too [illegible]

[illegible] of the [illegible] the sort- [illegible]

Merchantable fruit	bushels..	408
Culls (including windfalls)	do....	98.75
Percentage of merchantable fruit		80.5

The crop from 17 untreated Ben Davis trees in the same block was similarly sorted, and gave results as follows:

Merchantable fruit	bushels..	7
Culls (including windfalls)	do....	90.7
Percentage of merchantable fruit		7.2

It will be seen that of the crop from the unsprayed trees, 97.7 bushels, only 7 bushels were merchantable. In practice, the cost of labor for gathering and sorting such fruit would be more than its value, and the crop from the unsprayed trees would be, therefore, practically a complete loss, except for cider or evaporation.

In the same orchard the fruit from a block of 69 sprayed Winesap trees was sorted, as in the case of the Ben Davis, yielding—

Merchantable fruit	bushels..	255
Culls (including windfalls)	do....	36.5
Percentage of merchantable fruit		87.4

The crop from 10 unsprayed Winesap trees yielded as follows:

Merchantable fruit	bushels..	6.75
Culls (including windfalls)	do....	10.25
Percentage of merchantable fruit		39.7

The fruit classed as merchantable on the unsprayed Winesaps, namely, 6.75 bushels, was notably smaller than on the sprayed trees, 731 apples being required to fill a barrel as against 612 apples from the treated trees.

RESULTS IN MISSOURI.

In the Hansell orchard at Fordland, Mo., the fruit from 49 sprayed Jonathan trees, when classified, gave the following results:

Merchantable fruit	bushels..	121.5
No. 1's	do....	108
No. 2's	do....	13.5
Culls (including windfalls)	do....	11.29
Percentage of merchantable fruit		91.4

From 34 unsprayed Jonathans the yield was—

Merchantable fruit	bushels..	51
No. 1's	do....	24
No. 2's	do....	27
Culls (including windfalls)	do....	39.6
Percentage of merchantable fruit		56.2

Practically all the injury was due to the codling moth.

In the same orchard the fruit from 39 sprayed Gano trees gave results as follows:

Merchantable fruit	bushels..	258
No. 1's	do....	207
No. 2's	do....	51
Culls (including windfalls)	do....	37.37
Percentage of sound fruit		87.3

From 14 unsprayed Gano trees the yield was as follows:

Merchantable fruit	bushels..	42
No. 1's	do....	21
No. 2's	do....	21
Culls (including windfalls)	do....	39.5
Percentage of sound fruit		51.5

MATERIALS FOR SPRAYING.[a]

Bordeaux mixture with an arsenical added is the most effective treatment for the principal diseases of the fruit and foliage of the apple and for the codling moth. This combined fungicide and insecticide intelligently applied to the trees in the form of a spray should enable the orchardist to protect from the attack of these pests from 85 to 95 per cent of his crop, as has been demonstrated by these tests and shown in the earlier pages of this bulletin.

BORDEAUX MIXTURE.

Bordeaux mixture is composed of copper sulphate (bluestone) and quicklime, with a certain quantity of water. The amounts of copper sulphate and of lime to be used with a given quantity of water vary somewhat, according to the kind of plants or trees to be sprayed and the disease to be treated. When used on the apple the following formula is quite satisfactory for general orchard work:

Copper sulphate (bluestone)	pounds..	5
Quicklime	do....	5
Water to make	gallons..	50

[illegible] formula was used throughout the bitter-rot work in [illegible] weaker mixture composed of 4 pounds of [illegible] gallons [illegible] water was mostly used [illegible] would be less [illegible] to be the

---

[a] [illegible] of spray [illegible] Use in Pre- [illegible] insecticides [illegible] s," by C. L.

Directions for making.—If large quantities of Bordeaux mixture are to be used, stock solutions of the bluestone and lime should always be prepared, thus saving the time necessary to dissolve the materials. A stock solution of the copper sulphate may be made by dissolving it at the rate of 1 pound to each gallon of water. Fill a 50-gallon barrel two-thirds or three-fourths full of water, and place a sack (or box with perforations in the bottom and sides) containing 50 pounds of copper sulphate in the upper part of the barrel, suspending it by a string or copper wire. In from twelve to twenty-four hours the sulphate will have entirely dissolved, and the sack or box should be removed and enough water added to fill the barrel. After slight stirring, the solution is ready for use. The stock lime may be prepared by slaking 50 pounds in a barrel or other vessel, and finally adding water to make 50 gallons. In slaking the lime, sufficient water should be used to prevent burning, but not enough to drown it, and the mass should be continually stirred with a shovel or spading fork until a thin paste is formed. Stock preparations of both the lime and bluestone may, during warm weather, be prepared at twice this strength, that is, 2 pounds to each gallon of water, but it is difficult to slake more than 50 pounds of lime in a barrel, and when a larger quantity is to be prepared a box in which the lime may be spread out should be used. Barrels containing stock solutions should be kept tightly covered to prevent as much as possible the evaporation of the water, which would give a more concentrated stock solution. Preparatory to use, any water known to have been lost by evaporation should be added, to maintain the proper strength. In making Bordeaux mixture take the necessary quantities of the stock copper sulphate and the stock lime solutions to give the formula in the total amount of water to be used, and place each in separate elevated dilution tanks, which should hold half as much as the total capacity of the spray tank. Thus, if the spray tank holds 200 gallons each dilution tank should hold 100 gallons, and according to the above formula 20 pounds of copper sulphate (20 gallons of the stock solution) and 20 pounds of lime (20 gallons of the stock solution) would be required. To each dilution tank, water should be added (one-half the total amount of spray) and, after stirring, the diluted ingredients are allowed to run through separate hose or troughs attached to faucets at or near the bottom of the tanks, into the strainer on the spray tank, where the two solutions come together, producing the Bordeaux mixture; or, the diluted solutions may be run directly into a mixing tank alongside, the Bordeaux mixture being conducted thence by a hose directly to the spray tank. In extensive operations the latter method is perhaps to be preferred, as more than one batch of the Bordeaux mixture may be prepared somewhat in advance of the arrival of the spray wagon, effecting a slight saving in time. Only the quantity which can be used during the day should be mixed, as the Bordeaux mixture deteriorates on standing.

In case the dilution tanks are not elevated to admit of filling the spray tank by gravity, the diluted solutions must be dipped and poured into the latter by hand, a bucketful of each simultaneously. This method is only advisable in small operations, where a few barrels at most are needed.

The stock solutions should never be poured together before being diluted, as a coarse, heavy, unreliable mixture will result instead of the light, flocculent preparation that characterizes properly made Bordeaux mixture.

It is important that Bordeaux mixture should be thoroughly strained in order to keep out any coarse particles that would clog the spray nozzles, and it is a good practice to strain the stock solution of lime upon pouring it into the dilution tank. The best material for a strainer is brass wire netting of about 20 meshes to the inch.

Mixing platform for Bordeaux mixture.—In the preparation of Bordeaux mixture in any considerable quantities, some form of elevated platform is almost indispensable, so that the diluted solutions or the mixture may be conducted by gravity directly to the spray tank on the wagon. The platform should be amply large to accommodate the necessary barrels and tanks (at least 10 by 12 feet). Strong and durable materials should be used in its construction, and a well-made platform should last for several years.

The water supply.—An ample water supply will often be at hand in or near the orchard, and the mixing platform must be constructed convenient to it. A supply through pipes or from a water tank is a desirable part of the outfit. The water tank may be separate, as on a windmill tower, or may be placed on the mixing platform above the level of the top of the dilution tanks.

This may be kept filled with a hand pump, but preferably with a pump run by windmill or other form of power. By these means the dilution tanks are most conveniently filled. A cheaper but less convenient way is to pump the water directly from a well, spring, or pond into the dilution tank. If a hillside is available it will be convenient to construct the platform against the hill, a road being made on the lower side as a driveway for the spray wagon, while the chemicals may be delivered at the upper side. A good spring of water, somewhat above the platform, furnishes an ideal location, the water being conducted by troughs or pipes into the water tank on the platform. Sometimes the water is drawn from a pond beneath the edge of the platform by means of a chain pump and delivered through a trough into the tanks and barrels. This is an excellent arrangement where the water supply is thus convenient, but lacks the desirable feature of a storage water tank.

ARSENICALS.

Several arsenical poisons are available for use, such as Paris green, Scheele's green, arsenite of lime, and arsenate of lead. These all contain arsenic and destroy insects which eat them with their food. In the work herein reported Paris green and arsenate of lead were used. A good quality of Paris green is very satisfactory, and this poison is perhaps more generally used than all other arsenicals combined. It should be used on apple at the rate of about 1 pound to 150 gallons of water or Bordeaux mixture, in which case it is simply added to the mixture, having previously been worked into a paste with water, to insure its more thorough distribution in the fungicide. Many growers use it at the rate of 1 pound to 100 gallons of spray, but there is danger of injury to apple foliage at this strength. When used alone in water the milk of lime from slaking 2 or 3 pounds of good stone lime for each 50 gallons should be added, which will neutralize any free arsenic and prevent burning. The same result is secured by the excess of lime in the Bordeaux mixture.

The arsenate of lead was purchased from the manufacturer and used at the rate of 2 pounds for each 50 gallons of Bordeaux mixture. This arsenical, as found on the market, usually occurs in the form of a thick paste, which must be entirely worked free in a small amount of water before being added to the spray tank.

Arsenate of lead has been found preferable to Paris green by some experimenters, as a much greater quantity may be used without injury to the foliage, and it adheres longer. However, when used with Bordeaux mixture Paris green is not readily washed off by rains, is apparently as satisfactory as the former, and at the strength used costs less.

Scheele's green is similar to Paris green, but contains no acetic acid. Being a finer powder, it remains in suspension longer, and costs about one-half less.

Arsenite of lime is much the cheapest of the arsenicals used in spraying, and has been found to be quite efficient. It may be prepared according to the following formula:

White arsenic	pound..	1
Sal soda (crystals)	pounds..	4
Water	gallon..	1

All of the ingredients are boiled together for a few minutes, or until dissolved, and any water lost by evaporation added. This constitutes a stock solution, which will keep indefinitely, 1 pint being used with each 40 or 50 gallons of Bordeaux mixture or water. If used with water, the milk of lime from slaking 2 or 3 pounds of good stone lime must be added to produce the arsenite of lime and the color of the spray will show how thoroughly the spraying is being done. When used in Bordeaux mixture, no additional lime will be necessary.

In the use of poisons around the home the greatest care should at all times be exercised to prevent accidents. All packages and bottles containing poison should be plainly labeled and kept locked up. Utensils used in preparing poisons for sprays should be thoroughly washed after use.

EQUIPMENT FOR SPRAYING.

With other conditions favorable, the orchardist will not be able to secure satisfactory results in spraying unless he uses an efficient spraying outfit. The outfits in use in some orchards are a practical handicap to good work. There are now on the market many different makes of spray pumps, and some of them are quite efficient and successful. The orchardist can not afford to use any but the best.

The barrel type of pump is largely used in small to medium-sized orchards, and when properly fitted with hose of sufficient length, a good agitator, and nozzles, very effective work may be done. The pump, according to its design, is fitted to the end or side of an ordinary 50-gallon kerosene or similar barrel, which is mounted on a sled, on wheels, or, better, placed in a cart or wagon. One man is required to pump, and one or two men to handle the nozzles, depending on whether one or two leads of hose are used. A good barrel pump should supply two leads of hose, each with double nozzles. Tank outfits are mostly used in the larger orchards, but are very desirable for the small orchardist as well. These consist of rectangular or half-round tanks, flat on top, holding from 100 to 300 gallons of the spray mixture, fitted to the wagon in place of the wagon bed. Some growers use a 100 to 200 gallon hogshead tank placed on one end of the wagon. The barrel type of pumps may be used on these tanks, but it is better to use the larger tank pumps made for the purpose with suction hose. The hole in the top of the tank should be covered with a close-fitting lid to keep [illegible] leaves, twigs and other trash which would clog the [illegible]

[illegible] are much superior to the [illegible] the orchard interest [illegible] used. A much [illegible] hand pumps, [illegible] the tree and [illegible] be furnished [illegible] be done quite [illegible] where suitable [illegible]

A usual defect in spraying outfits is that the hose is not of sufficient length. Each lead of hose should be from 25 to 35 feet long (or from 50 to 75 feet where the second row on each side is to be sprayed) and provided with an 8 to 12 foot bamboo extension rod. This length of hose will permit the complete spraying of a tree before leaving it, insuring more thorough work than if but one side is sprayed at a time, and the amount of driving necessary will be reduced by one-half. (See fig. 7.) In spraying apple orchards an extension rod 10 feet in length will ordinarily be required, although shorter or longer rods are frequently used.

The nozzle is perhaps the most important part of the spraying outfit. There are many kinds of nozzles on the market, most of which are very unsatisfactory for orchard spraying. The Vermorel type of nozzle is best and should be used. The orchardist should not make the mistake of fitting an otherwise effective spray outfit with a poor nozzle. With hand-power pumps a double Vermorel nozzle for each lead of hose is satisfactory, but for power outfits triple or even quadruple nozzles may be used to good advantage. Many orchardists make the mistake of using nozzles with large apertures, thinking it desirable to discharge large quantities of the liquid. Small or medium-sized openings are required for producing a fine spray.

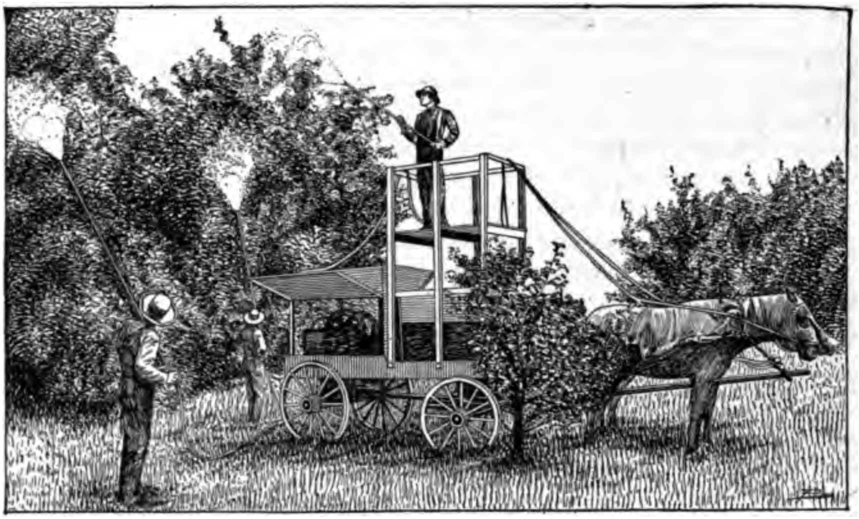


FIG. 7.—Power sprayer at work in the Gipple orchard.

In spraying high trees some form of elevated platform should be constructed on the wagon, on which one of the nozzle men may stand to spray the higher parts of the trees, the other men spraying from the ground as high as may be reached.

APPLYING THE SPRAY.

Sprays are preventive and not curative, and must therefore be applied before the injury becomes apparent. After a fungus has gained entrance to the foliage or fruit, it can not be reached and the diseased parts made sound again; but the infection may be prevented by coating the parts with a fungicide, such as Bordeaux mixture, which prevents the germination of the spores. Similarly, the codling moth may not be poisoned after it has burrowed into the fruit, but if the poison has been put in the calyx cavities before the calyx lobes close and has been sprayed on the foliage and fruit before the latter is entered by the larvæ, the destruction of the latter in large numbers is insured. Successful spraying, therefore, must be based on a knowledge of the diseases and insects to be controlled. With all of the affections here considered the work should be done in advance of their expected appearance in the orchard. There are two principal reasons why spraying in the hands of some is unsatisfactory, namely, failure to make the applications at the proper time and failure to thoroughly coat the trees and fruit with the mixture. In order to overcome the former difficulty the orchardist must be informed as to the nature of the malady or insect to be treated, and the latter may be overcome by maintaining proper equipment and by giving the necessary attention to thoroughness in spraying.

In the operation of spraying the liquid should be broken into a very fine mist. The nozzles should be so manipulated that every part of the foliage and fruit shall be uniformly covered with fine dots of the spray. It is not necessary that the foliage and fruit should be actually coated with the spray, but every portion should be thickly peppered with it. The higher and inner portions of the tree are commonly insufficiently sprayed, and while the liquid may actually be dripping from the lower branches, the upper parts of the tree may show but little of the spray.

The desired mist-like spray can ordinarily be secured only with high pressure at the pump. This pressure should be not less than 100 pounds, though this is not ordinarily obtained except with gasoline or other power outfits, which should supply a pressure of 125 pounds to 150 pounds. When hand pumps are used the pressure should be maintained as high as practicable, and never less than 75 pounds, in which case good nozzles become more essential for perfect work. To maintain this pressure will require constant hard work, and the tendency will be to allow the pressure to lighten. Except in spraying the tops of trees the nozzle men should never ride in the wagon, even while spraying the smallest trees. In order to reach the inner branches and the underside of the fruit and foliage the operator must spray from the ground, where he is free to walk around and under the trees. Many failures result from attempts to spray trees from the wagon as the outfit is being driven by.

INJURY TO FOLIAGE FROM SPRAYS.

Under certain conditions there may be in some years more or less russeting of the fruit and injury to foliage from the use of Bordeaux mixture, the injury mostly to the fruit following the applications made soon after the falling of the petals, for the apple scab. In several of the demonstration orchards in the Ozarks and in Nebraska injury to foliage and fruit was noticed. The russeting of the fruit, however, in most cases gradually disappeared as the apples developed, and at picking time was scarcely noticeable. In the Hansell orchard at Fordland a few of the apples at picking time were so russeted as to be undesirable for packing. Also some foliage injury resulted from the July and August applications of Bordeaux mixture and arsenicals, the foliage on the newer growth being in some cases scorched and browned around the edges of the leaves, and in others these became yellow, a small percentage falling. The foliage injury, however, was soon outgrown and by autumn the sprayed trees carried a heavy foliage, whereas the unsprayed trees were practically bare on account of injury from leaf-spot diseases, as already described. (See fig. 3.)

SCHEDULE OF APPLICATIONS.

The following schedule of applications is recommended as a system of orchard spraying for regions where all of the several affections herein considered are likely to occur, as in the Ozarks. The treatment for each of these troubles when considered alone has been given in connection with their discussion in the preceding pages, and where they do not all occur together the orchardist will be able to arrange a combination treatment for his particular troubles. With some varieties, practically immune to scab, the first application may be unnecessary, and the first treatment required is the second one of the schedule, i. e., for the codling moth. In localities, or with varieties immune to the bitter-rot, the last application of Bordeaux mixture may be omitted, or the amount of copper sulphate in the formula reduced.

First application.—Spray with Bordeaux mixture (5–5–50 formula) and an arsenical, after the cluster buds have opened, but prior to blooming. This is the first scab treatment, and is made to prevent that disease from infecting the fruit buds and young, unfolding leaves. The arsenical will destroy any larvæ feeding on the foliage or buds, such as canker worms, bud-moth, etc.

Second application.—Spray with Bordeaux mixture and an arsenical, as 2 pounds of arsenate of lead or 6 ounces of Paris green to 50 gallons of the Bordeaux mixture, immediately after the petals fall. This is the second treatment for scab and the first for the codling moth. Special pains must be taken to fill with the spray the calyx cavity of each little apple, where the poison will be retained to kill the young larvæ as they attempt later to enter the fruit. If this application has not been thoroughly made, a supplemental treatment should be given within a week and before the calyx lobes close, in order to further insure the poisoning of each calyx cavity and afford additional protection against the scab.

Third application.—Spray with Bordeaux mixture and an arsenical, as above, three weeks from the dropping of the petals. This treatment is especially important for destroying codling moth larvæ just as they are hatching from eggs placed here and there on the foliage and fruit. It is also an important treatment in the control of leaf-spot diseases, and in some seasons is necessary for the prevention of scab.

Fourth application.—Spray with Bordeaux mixture and an arsenical, as above, six or seven weeks after the petals fall. This is the first treatment for the bitter-rot and apple blotch diseases, and is also important for the control of leaf-spot. Where the preceding applications have been omitted and the weather conditions (hot and showery) indicate an early infection period, this treatment should perhaps be made a week earlier.

Fifth application.—Spray with Bordeaux mixture and an arsenical, as above, about nine weeks from the close of the blooming period or two weeks later than the fourth application. This constitutes the second application for the bitter-rot and apple blotch diseases, and the first for the second brood of the codling moth. It also affords further protection against leaf-spot.

Sixth application.—Spray with Bordeaux mixture and an arsenical, as above, about twelve weeks after the petals fall or three weeks after the fifth application. This constitutes the second application for the second brood of the codling moth and the third for the bitter-rot and apple blotch diseases.

FARMERS' BULLETINS.

The following is a list, by number, of the Farmers' Bulletins available for distribution. The bulletins entitled "Experiment Station Work" give in brief the results of experiments performed by the State experiment stations. Titles of other bulletins are self-explanatory. Bulletins in this list will be sent free to any address in the United States on application to a Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

22. The Feeding of Farm Animals. Pp. 40.
24. Hog Cholera and Swine Plague. Pp. 16.
27. Flax for Seed and Fiber. Pp. 16.
28. Weeds: And How to Kill Them. Pp. 30.
29. Souring and Other Changes in Milk. Pp. 22.
30. Grape Diseases on the Pacific Coast. Pp. 15.
32. Silos and Silage. Pp. 30.
33. Peach Growing for Market. Pp. 24.
34. Meats: Composition and Cooking. Pp. 31.
35. Potato Culture. Pp. 24.
36. Cotton Seed and Its Products. Pp. 16.
42. Facts About Milk. Pp. 32.
44. Commercial Fertilizers. Pp. 38.
47. Insects Affecting the Cotton Plant. Pp. 32.
48. The Manuring of Cotton. Pp. 16.
51. Standard Varieties of Chickens. Pp. 48.
52. The Sugar Beet. Pp. 48.
54. Some Common Birds. Pp. 48.
55. The Dairy Herd. Pp. 30.
56. Experiment Station Work—I. Pp. 30.
58. The Soy Bean as a Forage Crop. Pp. 24.
59. Bee Keeping. Pp. 48.
60. Methods of Curing Tobacco. Pp. 24.
61. Asparagus Culture. Pp. 40.
62. Marketing Farm Produce. Pp. 31.
63. Care of Milk on the Farm. Pp. 40.
64. Ducks and Geese. Pp. 55.
65. Experiment Station Work—II. Pp. 32.
66. Meadows and Pastures. Pp. 30.
69. Experiment Station Work—III. Pp. 32.
71. Essentials in Beef Production. Pp. 24.
72. Cattle Ranges of the Southwest. Pp. 32.
73. Experiment Station Work—IV. Pp. 32.
74. Milk as Food. Pp. 39.
77. The Liming of Soils. Pp. 24.
78. Experiment Station Work—V. Pp. 32.
79. Experiment Station Work—VI. Pp. 27.
80. The Peach Twig-Borer. Pp. 16.
81. Corn Culture in the South. Pp. 24.
82. The Culture of Tobacco. Pp. 22.
83. Tobacco Soils. Pp. 23.
84. Experiment Station Work—VII. Pp. 32.
85. Fish as Food. Pp. 32.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
91. Potato Diseases and Treatment. Pp. 15.
92. Experiment Station Work—IX. Pp. 30.
93. Sugar as Food. Pp. 31.
95. Good Roads for Farmers. Pp. 46.
97. Experiment Station Work—X. Pp. 32.
98. Suggestions to Southern Farmers. Pp. 48.
99. Insect Enemies of Shade Trees. Pp. 30.
100. Hog Raising in the South. Pp. 40.
101. Millets. Pp. 30.
102. Southern Forage Plants. Pp. 48.
103. Experiment Station Work—XI. Pp. 30.
104. Notes on Frost. Pp. 24.
105. Experiment Station Work—XII. Pp. 32.
106. Breeds of Dairy Cattle. Pp. 48.
107. Experiment Station Work—XIII. Pp. 32.
108. Saltbushes. Pp. 20.
110. Rice Culture in the United States. Pp. 28.
111. Farmers' Interest in Good Seed. Pp. 24.
112. Bread and Bread Making. Pp. 40.
113. The Apple and How to Grow It. Pp. 32.
114. Experiment Station Work—XIV. Pp. 28.
116. Irrigation in Fruit Growing. Pp. 48.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 30.
120. Insects Affecting Tobacco. Pp. 32.
121. Beans, Peas, and Other Legumes as Food. Pp. 38.
122. Experiment Station Work—XVI. Pp. 32.
124. Experiment Station Work—XVII. Pp. 32.
125. Protection of Food Products from Injurious Temperatures. Pp. 24.
126. Practical Suggestions for Farm Buildings. Pp. 48.
127. Important Insecticides. Pp. 46.
128. Eggs and Their Uses as Food. Pp. 40.
129. Sweet Potatoes. Pp. 40.
131. Household Tests for Detection of Oleomargarine and Renovated Butter. Pp. 10.
132. Insect Enemies of Growing Wheat. Pp. 38.
133. Experiment Station Work—XVIII. Pp. 32.
134. Tree Planting in Rural School Grounds. Pp. 32.
135. Sorghum Sirup Manufacture. Pp. 40.
137. The Angora Goat. Pp. 48.
138. Irrigation in Field and Garden. Pp. 40.
139. Emmer: A Grain for the Semiarid Regions. Pp. 16.
140. Pineapple Growing. Pp. 48.
142. Principles of Nutrition and Nutritive Value of Food. Pp. 48.
144. Experiment Station Work—XIX. Pp. 32.
145. Carbon Bisulphid as an Insecticide. Pp. 28.
147. Winter Forage Crops for the South. Pp. 40.
149. Experiment Station Work—XX. Pp. 32.
150. Clearing New Land. Pp. 24.
151. Dairying in the South. Pp. 48.
152. Scabies in Cattle. Pp. 32.
153. Orchard Enemies in the Pacific Northwest. Pp. 39.
154. The Home Fruit Garden: Preparation and Care. Pp. 16.
155. How Insects Affect Health in Rural Districts. Pp. 19.
156. The Home Vineyard. Pp. 22.
157. The Propagation of Plants. Pp. 24.
158. How to Build Small Irrigation Ditches. Pp. 28.
159. Scab in Sheep. Pp. 48.
161. Practical Suggestions for Fruit Growers. Pp. 30.
162. Experiment Station Work—XXI. Pp. 32.
164. Rape as a Forage Crop. Pp. 16.
165. Silkworm Culture. Pp. 32.
166. Cheese Making on the Farm. Pp. 16.
167. Cassava. Pp. 32.
168. Pearl Millet. Pp. 16.
169. Experiment Station Work—XXII. Pp. 32.
170. Principles of Horse Feeding. Pp. 44.
172. Scale Insects and Mites on Citrus Trees. Pp. 43.
173. Primer of Forestry. Pp. 48.
174. Broom Corn. Pp. 30.
175. Home Manufacture and Use of Unfermented Grape Juice. Pp. 16.
176. Cranberry Culture. Pp. 20.
177. Squab Raising. Pp. 32.
178. Insects Injurious in Cranberry Culture. Pp. 32.
179. Horseshoeing. Pp. 30.
181. Pruning. Pp. 39.
182. Poultry as Food. Pp. 40.
183. Meat on the Farm: Butchering, Curing, and Keeping. Pp. 37.
185. Beautifying the Home Grounds. Pp. 24.
186. Experiment Station Work—XXIII. Pp. 32.
187. Drainage of Farm Lands. Pp. 38.
188. Weeds Used in Medicine. Pp. 45.
190. Experiment Station Work—XXIV. Pp. 32.
192. Barnyard Manure. Pp. 32.
193. Experiment Station Work—XXV. Pp. 32.

194. Alfalfa Seed. Pp. 14.
195. Annual Flowering Plants. Pp. 48.
196. Usefulness of the American Toad. Pp. 16.
197. Importation of Game Birds and Eggs for Propagation. Pp. 30.
198. Strawberries. Pp. 24.
199. Corn Growing. Pp. 32.
200. Turkeys. Pp. 40.
201. Cream Separator on Western Farms. Pp. 23.
202. Experiment Station Work—XXVI. Pp. 32.
203. Canned Fruits, Preserves, and Jellies. Pp. 32.
204. The Cultivation of Mushrooms. Pp. 24.
205. Pig Management. Pp. 45.
206. Milk Fever and Its Treatment. Pp. 16.
208. Varieties of Fruits Recommended for Planting. Pp. 48.
209. Controlling the Boll Weevil in Cotton Seed and at Ginneries. Pp. 32.
210. Experiment Station Work—XXVII. Pp. 32.
211. The Use of Paris Green in Controlling the Cotton Boll Weevil. Pp. 23.
213. Raspberries. Pp. 38.
215. Alfalfa Growing. Pp. 40.
217. Essential Steps in Securing an Early Crop of Cotton. Pp. 16.
218. The School Garden. Pp. 40.
219. Lessons from the Grain Rust Epidemic of 1904. Pp. 24.
220. Tomatoes. Pp. 32.
221. Fungous Diseases of the Cranberry. Pp. 16.
222. Experiment Station Work—XXVIII. Pp. 32.
223. Miscellaneous Cotton Insects in Texas. Pp. 24.
224. Canadian Field Peas. Pp. 16.
225. Experiment Station Work—XXIX. Pp. 32.
226. Relation of Coyotes to Stock Raising in the West. Pp. 24.
227. Experiment Station Work—XXX. Pp. 32.
228. Forest Planting and Farm Management. Pp. 22.
229. The Production of Good Seed Corn. Pp. 24.
231. Spraying for Cucumber and Melon Diseases. Pp. 24.
232. Okra: Its Culture and Uses. Pp. 16.
233. Experiment Station Work—XXXI. Pp. 32.
234. The Guinea Fowl. Pp. 24.
235. Preparation of Cement Concrete. Pp. 32.
236. Incubation and Incubators. Pp. 32.
237. Experiment Station Work—XXXII. Pp. 32.
238. Citrus Fruit Growing in the Gulf States. Pp. 48.
239. The Corrosion of Fence Wire. Pp. 32.
241. Butter Making on the Farm. Pp. 32.
242. An Example of Model Farming. Pp. 16.
243. Fungicides and Their Use in Preventing Diseases of Fruits. Pp. 32.
244. Experiment Station Work—XXXIII. Pp. 32.
245. Renovation of Worn-Out Soils. Pp. 16.
246. Saccharine Sorghums for Forage. Pp. 37.
247. The Control of the Codling Moth and Apple Scab. Pp. 21.
248. The Lawn. Pp. 20.
249. Cereal Breakfast Foods. Pp. 36.
250. The Prevention of Wheat Smut and Loose Smut of Oats. Pp. 16.
251. Experiment Station Work—XXXIV. Pp. 32.
252. Maple Sugar and Sirup. Pp. 36.
253. The Germination of Seed Corn. Pp. 16.
54. Cucumbers. Pp. 30.
55. The Home Vegetable Garden. Pp. 4[illegible]
[illegible]parat. [illegible] Table
[illegible] 48.
[illegible]
[illegible] Red Clover, [illegible]
[illegible]attle Tick. Pp. 2[illegible]
[illegible]ment Station [illegible]
[illegible]nformat[illegible]
[illegible] p. 4[illegible]

267. Experiment Station Work—XXXVII. Pp. 32.
268. Industrial Alcohol: Sources and Manufacture. Pp. 45.
269. Industrial Alcohol: Uses and Statistics. Pp. 29.
270. Modern Conveniences for the Farm Home. Pp. 48.
271. Forage Crop Practices in Western Oregon and Western Washington. Pp. 39.
272. A Successful Hog and Seed-Corn Farm. Pp. 16.
273. Experiment Station Work—XXXVIII. Pp. 32.
274. Flax Culture. Pp. 36.
275. The Gipsy Moth and How to Control It. Pp. 22.
276. Experiment Station Work—XXXIX. Pp. 32.
277. The Use of Alcohol and Gasoline in Farm Engines. Pp. 40.
278. Leguminous Crops for Green Manuring. Pp. 27.
279. A Method of Eradicating Johnson Grass. Pp. 16.
280. A Profitable Tenant Dairy Farm. Pp. 16.
281. Experiment Station Work—XL. Pp. 32.
282. Celery. Pp. 36.
283. Spraying for Apple Diseases and the Codling Moth in the Ozarks. Pp. 42.
284. Insect and Fungous Enemies of the Grape East of the Rocky Mountains. Pp. 48.
285. The Advantage of Planting Heavy Cotton Seed. Pp. 16.
286. Comparative Value of Whole Cotton Seed and Cotton-Seed Meal in Fertilizing Cotton. Pp. 14.
287. Poultry Management. Pp. 48.
288. Nonsaccharine Sorghums. Pp. 28.
289. Beans. Pp. 28.
290. The Cotton Bollworm. Pp. 32.
291. Evaporation of Apples. Pp. 38.
292. Cost of Filling Silos. Pp. 15.
293. Use of Fruit as Food. Pp. 38.
294. Farm Practice in the Columbia Basin Uplands. Pp. 30.
295. Potatoes and Other Root Crops as Food. Pp. 45.
296. Experiment Station Work—XLI. Pp. 32.
297. Methods of Destroying Rats. Pp. 8.
298. The Food Value of Corn and Corn Products Pp. 40.
299. Diversified Farming Under the Plantation System. Pp. 14.
300. Some Important Grasses and Forage Plants for the Gulf Coast Region. Pp. 15.
301. Home-Grown Tea. Pp. 16.
302. Sea Island Cotton: Its Culture, Improvement, and Diseases. Pp. 48.
303. Corn Harvesting Machinery. Pp. 32.
304. Growing and Curing Hops. Pp. 39.
305. Experiment Station Work—XLII. Pp. 32.
306. Dodder in Relation to Farm Seeds. Pp. 27.
307. Roselle: Its Culture and Uses. Pp. 16.
308. Game Laws for 1907. Pp. 52.
309. Experiment Station Work—XLIII. Pp. 32.
310. A Successful Alabama Diversification Farm. Pp. 24.
311. Sand-Clay and Burnt-Clay Roads. Pp. 20.
312. A Successful Southern Hay Farm. Pp. 15.
313. Harvesting and Storing Corn. Pp. 32.
314. A Method of Breeding Early Cotton to Escape Boll-Weevil Damage. Pp. 20.
31[illegible] Progress in Legume Inoculation. Pp. 20.
[illegible] Experiment Station Work—XLIV. Pp. 32.
[illegible] Experiment Station Work—XLV. Pp. 32.
[illegible] Cowpeas. Pp. 28.
[illegible] Demonstration Work in Cooperation with Southern Farmers. Pp. 23.
[illegible] Experiment Station Work—XLVI. Pp. 32.
[illegible] Drag on Earth [illegible]

Issued May 10, 1907.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 284.

INSECT AND FUNGOUS ENEMIES OF THE GRAPE EAST OF THE ROCKY MOUNTAINS.

BY

A. L. QUAINTANCE,
OF THE BUREAU OF ENTOMOLOGY,

AND

C. L. SHEAR,
OF THE BUREAU OF PLANT INDUSTRY.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
Washington, D. C., March 6, 1907.

SIR: We have the honor to transmit herewith a paper entitled "Insect and Fungous Enemies of the Grape East of the Rocky Mountains," prepared by Mr. A. L. Quaintance, of the Bureau of Entomology, and Dr. C. L. Shear, of the Bureau of Plant Industry.

This bulletin treats of the principal insect and fungous enemies of the American varieties of grapes, giving the most successful methods of treatment at present known. It first states the nature of the insect enemies and the means of controlling them, then discusses the fungous parasites, including treatment, and in conclusion gives an account of spraying apparatus, with directions for applying spray mixtures. The reason for the joint publication arises from the fact that the remedial measures used in combating the insects and the fungous parasites are of such a nature that the applications can be combined and thereby result in a great reduction in cost of time and labor. We recommend the publication of this paper as a Farmers' Bulletin.

Respectfully,

L. O. HOWARD,
Chief of the Bureau of Entomology.
B. T. GALLOWAY,
Chief of the Bureau of Plant Industry.

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

Page.

Insect enemies 5
  Grape root-worm 6
    Distribution and destructiveness 6
    Description and life history 7
    Natural enemies 10
    Treatment 10
  Grape berry moth 12
    Distribution and destructiveness 12
    Description and life history 13
    Treatment 14
  Grape curculio 16
    Distribution and destructiveness 16
    Life history and habits 17
    Treatment 18
  Grape leaf-hopper 19
    Description and life history 19
    Remedial measures 21
  Grape leaf-folder 22
    Treatment 22
  Grapevine flea-beetle 23
    Treatment 24
  Rose-chafer 24
    Breeding grounds 25
    Life history 26
    Treatment 26
Insecticides 26
  Arsenicals 26
    Paris green 27
    Scheele's green 27
    Arsenate of lead 27
    Arsenite of lime 27
  Contact remedies 27
    Whale-oil soap 28
    Kerosene emulsion 28
Fungous diseases 28
  Black-rot 29
  Downy mildew 30
  Powdery mildew 32
  Anthracnose 34
  Ripe-rot 35
  Less important diseases 36
    Bitter-rot 36
    White-rot 36
    Crown-gall 37
    Root-rot 37
    Shelling 37
Fungicides 38
  Bordeaux mixture 38
  Preparation of Bordeaux mixture 38
  Nonstaining preparations 40
Spraying 41
  Spraying apparatus 41
    Power 41
    Pumps 45
    Nozzles 45
  Application of spray mixtures 46
  Quantity of mixture required and cost of treatment 48

ILLUSTRATIONS.

Fig. 1. Grape root-worm (*Fidia viticida*)
2. Grape berry moth (*Polychrosis viteana*)
3. Grape leaf, showing feeding marks of grape curculio beetles, and bunch of grapes infested with larvæ
4. Work of grape curculio (*Craponius inæqualis*) in berry of grape
5. Grape curculio (*Craponius inæqualis*)
6. Grape leaf-hopper (*Typhlocyba comes*)
7. Grape leaf-folder (*Desmia funeralis*)
8. Grapevine flea-beetle (*Haltica chalybea*)
9. Rose-chafer (*Macrodactylus subspinosus*)
10. The black-rot fungus (*Guignardia bidwellii*)
11. A bunch of grapes destroyed by black-rot
12. A grape leaf attacked by the downy mildew (*Plasmopara viticola*)
13. The fungus causing downy mildew
14. A bunch of young grapes partially destroyed by "gray-rot"
15. The fungus causing powdery mildew (*Uncinula necator*)
16. Grape shoot, showing spots produced by anthracnose (*Sphaceloma ampelinum*)
17. Portion of a bunch of grapes, showing the effect of anthracnose
18. Section of an anthracnose spot
19. Grapes attacked by the ripe-rot (*Glomerella rufomaculans*)
20. The fungus producing ripe-rot (*Glomerella rufomaculans*)
21. Elevated platform for making Bordeaux mixture
22. Cross section of strainer for Bordeaux mixture
23. A knapsack sprayer
24. A barrel-and-cart spraying outfit
25. A geared horse-power vineyard sprayer
26. A carbonic-acid-gas sprayer
27. A compressed-air sprayer in operation
28. A gasoline engine and pump made especially for spraying
29. Wagon and tank adapted to vineyard spraying
30. Adjustable rods and nozzles for vineyard spraying
31. A large hand spray pump with double vertical cylinders
32. A large hand spray pump with double horizontal cylinders
33. A vermorel spray nozzle
34. A grape leaf properly sprayed
35. A grape leaf improperly sprayed

B. P. I.—267.

INSECT AND FUNGOUS ENEMIES OF THE GRAPE EAST OF THE ROCKY MOUNTAINS.

INSECT ENEMIES.

All of the important insect enemies of the grape in the United States at the present time are native American species, feeding originally, as they do at the present day, on various wild species of grapes and related plants. With the planting of vineyards and the extension of the grape-growing industry many species attacked also the cultivated varieties, and some few have become exceedingly troublesome pests. Perhaps no horticultural crop so well illustrates the serious loss which may result from native species of insects attacking cultivated varieties of their natural wild food plants as does the grape. As a rule, varieties with a preponderance in parentage of the European grape (*Vitis vinifera*) are not vigorous growers in the Middle and Eastern States and suffer to a greater degree from insect attack than varieties with parentage of American vines. But these latter are not exempt and, with the exception of one or two insects, are equally subject to attack. The principal exception to be noted is the grape phylloxera, an aphide or "plant louse" which infests the roots and also the leaves of the grape and is especially injurious to vinifera or European varieties. Several species of American grapes and some of their hybrids and varieties, and other kinds to a less degree, are resistant to attack from this insect, and these are used as grafting stock for vinifera varieties in California and Europe, where the insect has been and is especially troublesome. It has been suggested that certain species or varieties of American grapes are resistant to the grape root-worm also, and although there is no evidence bearing on the question, the matter is of sufficient importance to warrant careful investigation.

Of the two hundred or more species of insects known to feed upon the grape in the United States, those treated herein include, with the exception of the phylloxera, those of principal importance, namely, the grape root-worm, grape berry moth, grape curculio, grape leaf-hopper, grape leaf-folder, grapevine flea-beetle, and rose-chafer. Grape insects are not less amenable to treatment than insect pests of other fruit crops, and the vineyardist may confidently expect to be able to keep them under control by the application of the remedies herein recommended. As the reader will learn in the following pages, the principal insect and fungous enemies of the grape may be controlled with material reduction of cost by timely and thorough applications of a combined insecticide and fungicide used in the form of a liquid spray. As in the control of most other insect pests, cultural methods are of very great importance. Vines kept in a vigorous, healthy condition by cultivations and fertilization are much better able to withstand insect attack than those grown under conditions of neglect.

THE GRAPE ROOT-WORM.

The grape root-worm (*Fidia viticida* Walsh), as the name indicates infests the roots of the grape, devouring more or less completely the smaller roots and rootlets and eating pits or burrows into the outer portion of the larger roots. It is the larva of a small, hairy, chestnut-brown beetle which makes its appearance in vineyards at about the close of the blooming period of such varieties of grapes as Concord, Niagara, Catawba, and Delaware. The beetles feed freely on the upper surface of the leaf, eating a series of patches or holes through to the lower surface, thus producing characteristic chain-like feeding marks, as shown in figure 1 at *h*, by which their presence in vineyards may be readily detected. The injury to the foliage, however, is quite unimportant compared to the work of the larvæ on the roots. When the larvæ are abundant the vines may be killed in the course of a season or two, but usually the plants will live longer, though making but a feeble growth and failing to produce profitable crops. The death of vines or the gradual failure of a vineyard should call for an examination of the foliage for the feeding marks of the beetles and of the roots for the work of the larvæ on these parts.

Distribution and Destructiveness.

The grape root-worm, or grapevine Fidia, is without doubt a native species, feeding originally on wild grapes, as it does at the present time. In addition to cultivated varieties of grapes it has also been recorded as feeding on the Virginia creeper (*Ampelopsis quinquefolia*) and the American red-bud (*Cercis canadensis*). In the literature of the species it is said to occur in Iowa, Missouri, Arkansas, Illinois, Kentucky, Ohio, New York, and New Jersey. In 1892 Doctor Horn gave the distribution of the insect as from the "Middle States to Dakota, Florida, and Texas." According to the records of the Bureau of Entomology the insect occurs in New York, Pennsylvania, Virginia, North Carolina, Ohio, Illinois, Kentucky, Missouri, Mississippi, Texas, and California. The species is therefore widely distributed in the Mississippi Valley and in the Eastern States, and occurs also in California.

This insect first came into notice as a pest of cultivated grapes in 1866, in Kentucky, by reason of injury to the foliage caused by the adults or beetles. This attack was the subject of a short note by Mr. B. D. Walsh in the Practical Entomologist.[a] The following year the species was described by Mr. Walsh and given the name it still bears.[a] Riley in 1879, in his First Report on the Injurious Insects of Missouri, regarded the insect as one of the worst pests of the vine in that State, where it occurred abundantly and was miscalled the rose bug (*Macrodactylus subspinosus*). In 1893 and subsequently the insect became very injurious in vineyards in northern Ohio, and was carefully investigated by Prof. F. M. Webster,[b] who showed that the larvæ or grubs of the beetle fed upon the roots of the vine, causing much more serious damage than was caused by the beetles in feeding upon the foliage. In 1900 the insect was discovered by Professor Slingerland[c] to occur in injurious numbers in vineyards in the Chautauqua grape belt in western New York, and during the three or four years following was carefully studied by him and also by Dr. E. P. Felt, and effective remedial measures were devised by extensive practical experiments. At the present time the grape root-worm continues to be a pest of importance in the vineyards of northern Ohio, the Erie grape belt in Pennsylvania, and the Chautauqua region of western New York. Throughout these regions the insect on the whole seems to be diminishing in importance, in part through natural agencies but more especially following adequate cultivation of vineyards and the use of sprays.

---

[a] Practical Entomologist, Vol. 1, p. 99 (1866).

The insect thrives best in vineyards which are neglected; in the absence of cultivation and timely spraying it is likely to become a serious pest in any vineyard throughout its range of distribution. This is especially the case in light, sandy soils and in regions where grape growing is a considerable industry.

Description and Life History.

Adult.—The beetle, or parent insect of the grape root-worm, is shown enlarged at *a*, figure 1. It is about one-fourth of an inch long, rather stout, with long legs, the body brownish in color and covered with grayish white hairs. The adults make their appearance in vineyards beginning about the close of the blooming period of the vines, which in the New York, Pennsylvania, and Ohio grape districts, during normal seasons, will be from about the 15th to about the 20th of June. The great majority of beetles will appear during the latter part of June and the first two or three weeks of July, though a few will be coming out during the latter part of July, and stragglers may appear for a month or six weeks later. In a given locality there will be some variation in the time of appearance, which will be earlier on light, sandy soils or warmer locations and later on heavier soils. In the course of a few days after emergence the beetles begin to feed, eating rows of holes in the upper surface of the leaf, as shown in figure 1 at *h*. After some days of feeding the females begin to deposit eggs, the number for an individual female varying considerably. Doctor Felt[d] has obtained egg-laying records of 156, 342, and 902 eggs, respectively, for three individuals, and the averages per insect from three lots of insects kept under observation were 141, 192, and 488, respectively, the average for the entire number being nearly 175 eggs per female. According to the same writer, about 45 per cent of the eggs of the individuals above mentioned were deposited during the first two weeks, and 73 per cent of the entire number were deposited during the first month after emergence. Beetles are to be found on the vines during a considerable period, owing to their longevity and to an irregularity in emergence, though, as stated, oviposition is largely done during the three or four weeks following emergence. Upon being disturbed many of the beetles will lose their hold upon the vines and fall to the ground in their efforts to escape detection. Advantage may be taken of this fact, as explained later, to collect the insects from the vines by jarring.

---

[a] Practical Entomologist, Vol. 2, pp. 87–88 (1867).
[b] Bul. 62, Ohio Agrl. Exp. Station (1895).
[c] Bul. 184, Cornell Univ. Agrl. Exp. Station (1900).
[d] Bul. 19, Office State Ent. of N. Y., p. 20 (1903).

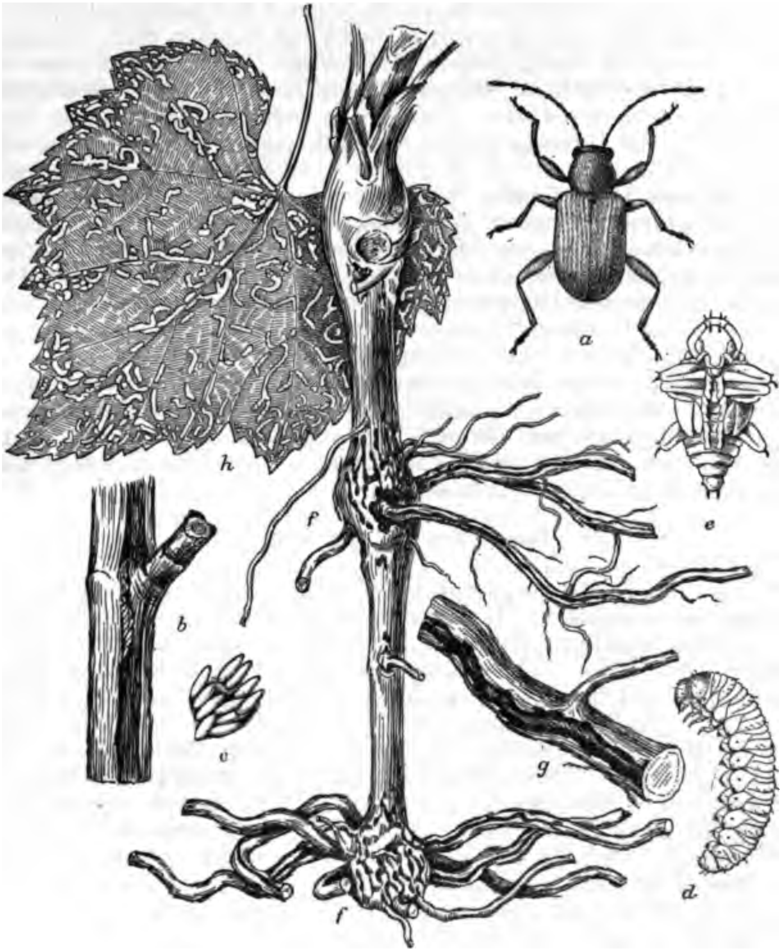


FIG. 1.—Grape root-worm (*Fidia viticida*): *a*, Adult or beetle; *b*, eggs on cane, about natural size; *c*, eggs, enlarged; *d*, full-grown larva; *e*, pupa; *f*, *f*, *g*, roots of grape, showing injury by larvæ; *h*, grape leaf, showing characteristic chain-like feeding marks made by beetles. *a*, *c*, *d*, *e*, Much enlarged; *b*, *g*, about natural size; *f*, *h*, reduced.

Egg.—Eggs are deposited in patches usually from 25 to 40, sometimes less, but rarely more, according to Slingerland, mostly under the bark of last year's wood, and may occur quite generally over the canes, some quite near to the upper wire of the trellis. As stated by Professor Webster[a], 700 eggs were found on a single vine, and 225 eggs from a section of a cane but 16 inches long. The eggs are nearly cylindrical in shape, tapering at each end; whitish when first laid, but soon becoming yellowish in color. The eggs are about one-twenty-fifth of an inch in length, and more or less concentrically arranged in patches. From 9 to 12 days are required for the eggs to hatch. See figure 1, at *b* and *c*, showing eggs on grape cane and more enlarged.

Larva.—On hatching, the larvæ drop to the ground. At this time they are about one-seventeenth of an inch in length, and from their small size are readily able to find their way through the soil. Although the powers of locomotion and endurance of the young larvæ are considerable, to enable them to overcome difficulties in reaching their food, many doubtless fail to do so and perish. When established on the roots, however, the grubs feed freely and grow rapidly. By fall the majority of them will be full-grown or nearly so. Upon the approach of cold weather they descend into the earth several inches, a few as much as a foot below the surface, and here construct oval earthen cells in which they pass the winter. With the approach of warm weather the larvæ ascend to a point near the surface, the immature ones completing their growth, and the pupal stage is entered mostly from about 2 to 3 inches below the surface of the soil and within a radius of 1½ to 2 feet from the base of the vine. The full-grown larva is about five-eighths of an inch long, the body whitish, resting in a curved position. The head is yellowish brown in color, with a transverse diameter somewhat less than that of the body. The spiracles or breathing pores along each side are well marked, varying from light to yellowish brown in color. As shown in figure 1, at *d*, the insect in this stage resembles in miniature one of the common white grubs, from which it may be distinguished by the dark food material in the abdomen of the latter.

Pupa.—The full-grown larva prepares an earthen cell, within which it shortly changes to the pupa or "turtle" stage. In this condition the insect is soft and helpless, and the earthen cells are readily broken open and the pupæ crushed or otherwise killed by stirring the soil. As stated, the majority of the larvæ pupate about 2 or 3 inches below the surface of the ground, and this makes possible their destruction in large numbers by timely cultivations, as will be explained under the discussion of remedies. Pupation is perhaps at its height just before the blossoms of the grape begin to open, but the vineyardist may determine the period with exactness by examining the earth around the base of infested vines to ascertain the proportion of pupæ and larvæ present. Throughout the Chautauqua, Erie, and Ohio grape belts, during normal seasons, the insects will be in the pupal stage in maximum numbers during the first two or three weeks of June, varying somewhat, however, according to season and the character of the soil, being earlier on sandy and later on clay soils. The pupa is shown in figure 1 at *e*. It is from one-fourth to one-third of an inch long, whitish in color, but with a pinkish coloration about the head, thorax, and caudal portion. On the head, body, and appendages are spines, as shown in the figure. The pupal stage lasts about two weeks.

---

[a] Bul. 62, Ohio Agrl. Exp. Station, p. 82 (1895).

Natural Enemies.

No parasitic enemies of the beetles, pupæ, or larvæ are recorded, but Professor Webster, in Ohio, has bred from the eggs two species of small hymenopterous wasps, namely, *Fidiobia flavipes* Ashm., and *Brachysticha fidiæ* Ashm., which he found to be doing most excellent work. The former parasite was also bred from eggs by Slingerland in New York State in 1905. Eggs are also attacked by two or three species of small mites, which destroy them by extracting the contents. The common little brown ant, *Lasius brunneus* var. *alienus*, also has been observed to feed upon the eggs, and several predaceous insects were found by Dr. E. P. Felt in the course of his field work in New York occurring in the soil infested by root-worms, and he thought it probable that these preyed upon this species. The beetles are no doubt fed upon by insectivorous birds and barnyard fowls, which also are known to feed upon the pupæ exposed in cultivating.

Treatment.

The insect may be fought in three important ways, namely, by poisoning the adults with an arsenical spray, jarring them from the vines onto sheets, and destroying the pupæ in the soil by cultivation.

Poisoning.—Shortly after emergence the beetles begin to feed upon the foliage, eating holes in the upper surface of the grape leaves, and hence may be readily poisoned. The use of poisons was recommended by Mr. Marlatt[a] in 1895, while Messrs. Slingerland and Johnson have shown by extensive practical experiments that the numbers of the pest may be greatly reduced in this way, and that poisoning in conjunction with cultivation, to be later mentioned, affords almost complete protection from its injuries. To be effective, however, the poisoned spray must be applied at the right times and with great thoroughness. The beetles begin to put in an appearance at about the close of the blooming period. Careful watch should be kept, and upon the first signs of the chain-like feeding marks on the leaves the vines should be thoroughly sprayed with a poison. A second application should be made in a week or ten days. These applications are intended to poison the newly emerged beetles during their first feeding and before they have deposited their eggs to any extent. If applications be delayed two or three weeks beyond the time indicated, a considerable percentage of the eggs will have been deposited, and the treatments will lose much of their value. Vineyardists having this pest to contend with should not make the mistake of spraying a little too late, but should have everything in readiness to begin applications upon the first appearance of the beetles. The beetles plainly avoid feeding on foliage sprayed with Bordeaux mixture or arsenate of lead, seeking the unsprayed leaves as much as possible. It is therefore especially necessary to make applications with great thoroughness, poisoning as nearly as possible the upper surface of every leaf, so that the beetles will be poisoned or forced to leave the vines for food. This desired thoroughness of treatment is not obtained as a rule by vineyardists, and greater care should be exercised in this work. In commercial vineyards the tendency will be to hurry through the work, covering 12 or 15 acres per day, using an insufficient amount of spray. With the spraying machinery in common use 7 to 8 acres per day is about all that may be covered with the desired thoroughness, and about 125 gallons of spray mixture should be applied per acre. In spraying for the grape root-worm, the poison should always be applied in Bordeaux mixture, which is used in the control of fungous diseases, as elsewhere considered in this bulletin. The several arsenical poisons which may be used are discussed on pages 26 and 27.

---

[a] Yearbook U. S. Dept. of Agriculture, 1895, p. 393.

Destruction of beetles by jarring.—Doctor Felt has made extensive practical tests of jarring the beetles from the vines and catching them on sheets or special forms of catchers run under the plants or along the rows, and considers this to be an effective plan of controlling the pest, the jarring of the vines causing many of the beetles to fall in their efforts to escape detection. A sheet of canvas placed on the ground beneath the vines will serve to catch the beetles, but where work of this kind is done on a large scale special apparatus must be provided. There is room for considerable ingenuity in constructing catchers that will suit individual conditions. Concerning the value of jarring, Doctor Felt says:[a] "Our experience with collectors has demonstrated the practicability of catching the beetles, and we recommend this operation for all badly infested sections, and that the collecting be begun as soon as the beetles appear on the vines in any numbers, say where there are 12 or 15 on one. The operation should then be repeated at intervals of 5 to 7 days till the vines have been gone over two, three, or four times, depending somewhat on the number of insects which are captured. It will be found that it is much easier to catch the beetles on warm days, when it should be done, than in cool weather."

Destruction of pupæ by cultivation.—While the grape root-worm may be present in well cultivated vineyards, it is much less destructive than in vineyards which receive indifferent cultivation or total neglect. It has long been known that much good may be done in controlling insects which live underground by breaking open their pupal cells and crushing or otherwise killing the helpless pupæ. The importance of this work in the destruction of pupæ of the grape root-worm was first pointed out by Professor Slingerland in his studies of this pest in the Chautauqua grape belt, and subsequent experiments, confirmed by practical experience, have shown that this is a very important method of reducing the numbers of insects. After the larvæ have become full grown the great majority pupate but 2 or 3 inches below the surface of the soil, and mostly within a radius of 1½ or 2 feet from the base of the vine. In this stage the insects are quite helpless, and are killed in large numbers by a thorough breaking up of the soil around the base of the plants. As stated, the insect will be in the pupal stage in maximum numbers just before the period of blooming of the vines, and the cultivating should be done at this time. In the Ohio, Pennsylvania, and New York grape districts this will be about the middle of June, the time varying somewhat according to the character of the season and of the soil. The details of this work are very important and require explanation.

With the last cultivation in the fall the earth should be thrown to the vines on each side, forming a ridge along the row. The following spring the larvæ in making their way toward the surface of the soil to pupate will mostly work up in this ridge of earth, above the surface of the roots, and there enter the pupal stage. The cultivation of the vineyard in the spring should be so adjusted that this ridge of earth may be thrown away from the vines when most of the insects are in the pupal stage, as one of the regular cultivations. An implement known as a "horse-hoe," generally used in vineyards, may be employed to great advantage in this work; but as it is not practicable to remove the earth from immediately around the vine owing to danger of injury, it is necessary to follow the horse-hoe at once and remove the earth with a hand-hoe. The latter work is also done as a part of the regular vineyard treatment to keep down weeds and grass, and is timed so as to supplement the plowing with the horse-hoe for the insect. Following the removal of the ridge of earth from along the vines, it is well to keep the ground stirred at frequent intervals by means of a cultivator to further insure the destruction of the pupæ.

---

[a] Bul. 19, Office State Ent. of N. Y., p. 37 (1903).

GRAPE BERRY MOTH.

The larva of the grape berry moth (*Polychrosis viteana* Clem.) infests the berry or fruit of the grape. The first generation attacks and webs together the grape clusters even before the blossoms open or soon after the grapes are set. Later-appearing larvæ bore into the green or ripening fruit and produce a purplish spot much resembling in appearance the injury due to the black-rot fungus, with which it is frequently confused. Within the fruit the larvæ feed on the pulp and seeds, passing from one grape to another, and several of these discolored and shriveling berries will often be found more or less webbed together with numerous particles of larval excrement, and sticky with exuding grape juice. Other insects attack the fruit of the grape, such as the grape-seed insect (*Isosoma vitis* Saunders), whose larvæ feed on the seeds, causing the berries to shrivel late in the summer, and the grape curculio (*Craponius inæqualis* Say), whose injury closely resembles that of the grape berry moth and is considered on a later page. But the principal cause of wormy grapes throughout the country is the larva of the species under consideration. Until recently it was thought that our grape berry moth was introduced from Europe many years ago. But Messrs. Slingerland and Kearfott have shown,[a] by careful study of this insect and related species, that the insect infesting American vineyards is quite distinct from the European form (*Polychrosis botrana* Schiff). These gentlemen have also shown that the American grape berry moth does not feed upon sumac, as was formerly held, and consider it very probable that the grape is the sole food of this species. This important fact greatly simplifies the question of its control, for if the species had other food plants vineyards would be reinfested from outside sources despite thorough treatments.

Distribution and Destructiveness.

The American grape berry moth occurs from Canada south to the Gulf and westward to California. It is very generally distributed over this area, and wherever the grape is grown it is more than likely to be found. For a number of years the pest has been troublesome in Ohio vineyards, and also more or less locally in the Erie grape belt and in New York State. In 1902, according to Slingerland, it was destructive all through the Chautauqua grape belt, and was equally destructive through a large part of this area during the two succeeding years. At the present time the insect is destructive in individual vineyards here and there throughout the Chautauqua, Erie, and northern Ohio grape districts, causing a loss of many thousands of dollars annually. In some vineyards a loss of from 25 to 50 per cent of the crop is not infrequent, and in occasional instances the destruction of the fruit is practically complete.

---

[a] Bul. 223, Cornell Univ. Agrl. Exp. Sta. (1904).

Description and Life History.

The grape berry moth is small, the wings expanding not quite one-half inch. The general color is purplish brown, the wings with markings as shown in figure 2. Moths appear in the spring from hibernating pupæ, beginning about the time the shoots of the grape are pushing out, and continuing to emerge for some weeks. The earlier-appearing individuals deposit their eggs on the blossom clusters, while those coming out after the blossoms are shed oviposit on the clusters of young grapes.

The minute scalelike eggs of the first brood of moths are difficult to find, as at this time they are relatively scarce, but may be readily detected during summer as a glistening or whitish spot on the surface of the berries. The larvæ of the first generation feed upon the blossoms and small berries, webbing them together more or less and producing a more or less ragged bunch of grapes, or the cluster may be almost entirely destroyed. The capabilities of the larvæ for injury at this time are thus seen to be much greater than is the case with larvæ of the later broods, by which individual berries are attacked. The spring brood, however, is usually quite small; evidently there is a heavy mortality of the insect during the preceding fall and winter. About 3 weeks are required for a larva to complete its growth in summer, when it is about three-eighths of an inch in length, slender, light greenish to purplish in color, the head slightly bilobed, greenish above, and brownish in front, the thoracic feet blackish. When ready to pupate the larvæ go to the leaves, and a small portion is cut loose, except along one side, and bent over and fastened down with silk. Beneath this a thin, whitish, silken cocoon is spun, and in 3 to 4 days the larva changes to a light greenish brown pupa, from which the moth will emerge in some 12 to 14 days. The larva and curious cocoon and pupa are shown in figure 2, considerably enlarged. Moths of the second and later generations deposit their eggs on the developing grape berries, and the resulting larvæ bore into these, feeding on the pulp and seeds, the entrance point of the berry being marked by a purplish spot, which renders their detection quite easy. In the Chautauqua and Erie grape belts, and probably in northern Ohio, moths of the second generation will begin coming out and ovipositing about the first week or ten days of July, continuing for some weeks, the first and second broods overlapping. By this time the insects will have increased greatly in numbers, and the larvæ will be attacking almost exclusively the berries of the grape, for which reason their work is much more conspicuous. Seco brood larvæ infest the grape during July and August, the la appearing individuals probably not developing to moths but hil nating in the pupal condition. Many of the earlier-appearing ins of this brood appear to complete their life cycle, and moths devel giving rise to a third generation of larvæ. According to the ob vations of Mr. Fred Johnson, of the Bureau of Entomology, at Nc East, Pa., practically a full third brood was produced during 1 On September 7, according to this observer, larvæ one-third to c half grown were very numerous, from 80 to 90 per cent of the l ries in many clusters having been injured. Egg shells were v abundant on the fruit, which at this time was beginning to co Many of the eggs had been parasitized by what is probably *Tri gramma pretiosa* Riley, a minute hymenopterous fly which ovipo in the eggs of many species of lepidopterous insects. A few la were found in berries by Mr. Johnson as late as October 17, tho practically all of the larvæ had left the fruit. They were fo mostly on the leaves, which had already fallen to the ground, wh

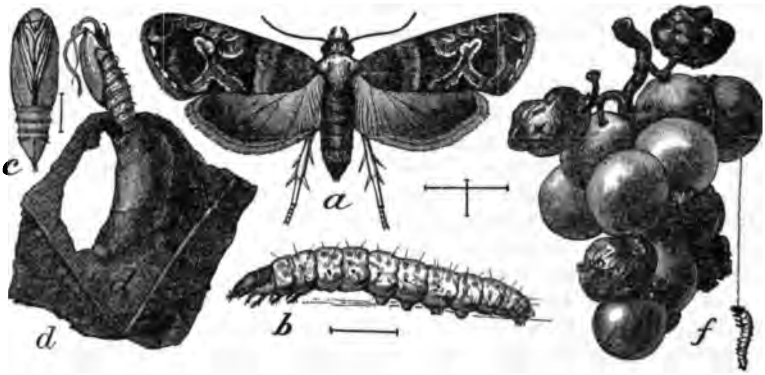


FIG. 2.—Grape berry moth (*Polychrosis viteana*): *a*, Adult or moth; *b*, larva; *c*, pupa; *d*, folded with pupa shell projecting from case cut from the leaf; *f*, grapes, showing injury, and larva pended by its silk. All much enlarged, except *f*, somewhat reduced. (From Marlatt.)

it appeared the larvæ went to pupate, scarcely any being found the foliage still attached to the vines. In the Middle and South States it is inferred that there may be each year three full bro or perhaps more, but as yet the insect has not been studied in territory.

Treatment.

Poisons.—The use of arsenical poisons against the first brood the grape berry moth was recommended by Mr. Marlatt, of Bureau of Entomology, in 1895.[a] Since this time the recommen tion has been amply justified in the experience of numerous v yardists, who, in connection with the fight against the grape r worm, found that their early sprayings for this pest were also c trolling the grape berry moth. Professor Slingerland reports instance in which three timely applications of arsenate of lead, at rate of 10 or 12 pounds to 100 gallons of water, gave almost absolute protection during the rest of the season. Doctor Felt records[a] that the application of arsenate of lead along with Bordeaux mixture, for the grape root-worm, shortly after the blossoms had fallen and before the berries had grown to the size of a pea, resulted in a decrease of 50 per cent in the injury to fruit by the berry moth.

---

[a] Yearbook, U. S. Dept. of Agriculture, 1895, p. 404.

While definite experiments with poisons in the control of this pest appear not yet to have been reported,[b] the experience above given indicates their great usefulness. As would appear from the life history of the insect, most effective work may be done by destroying the first brood larvæ, which feed in the clusters of blossoms and berries. The first treatment should be made just before the blossoms are ready to open, and the second just after the blossoms have fallen. A third treatment in a week or ten days is also advisable in badly infested vineyards. In all these treatments special care should be exercised to force the spray well through the clusters of blossoms and young fruit. It will be noted that the second and third treatments for the grape berry moth will coincide with the first and second treatments for the grape root-worm, and the arsenicals recommended for that insect will be equally satisfactory for the grape berry moth. (See page 10.)

Picking infested berries.—This practice is often followed by vineyardists, and is especially directed against larvæ of the second brood. The infested spotted green berries, which are readily seen, should be carefully searched for and destroyed. This practice will lessen injury from a possible later brood, and if carefully followed would reduce the insects materially in the vineyard from year to year.

Bagging clusters.—Inclosing each cluster of grapes in a paper bag soon after the blossoms have fallen should protect them from injury from second and third-brood larvæ, and would also afford protection from the rose-chafer and from black-rot. This practice is especially useful in the small home vineyard.

Gathering fallen leaves.—The fact that the insect passes the winter in fallen leaves has led to the recommendation that these be raked up and burned. From Mr. Johnson's observations it would appear important to collect these early in the fall, as the pupæ are to be found mostly on the 10 or 15 per cent of leaves which fall first, and great care must be taken to collect those leaves more or less imbedded in the soil. After remaining on the ground for a while, probably many of the cocoons break off from the leaves and would thus not be collected with the leaves. It is probable also that many of the insects could be destroyed by covering the leaves with soil early in the fall.

---

[a] Bul. 19, Office State Ent. of N. Y., p. 31 (1903).

[b] Since this article was written, definite experiments in spraying for the grape berry moth have been reported by Profs. H. A. Gossard and J. S. Houser in Circular 63 of the Ohio Agricultural Experiment Station. These gentlemen have shown that the insect may be largely controlled by three applications of an arsenical, with the addition of some form of soap to make the spray more adhesive, the time of making applications being practically as recommended above.

GRAPE CURCULIO.

The grape curculio (*Craponius inæqualis* Say) is one of the "snout beetles" belonging in the same family (Curculionidæ) as the so-called plum curculio. The parent beetle deposits her eggs in little cavities which she eats into the grapes, and the resulting larvæ feed upon the pulp and seeds, producing an injury quite similar to that done by the grape berry moth. The beetles cut small, rather characteristic holes in the grape leaves when feeding, and the berries often show a purplish coloration at the point punctured in egg-laying, as shown in figure 3. If infested berries be examined it will be readily possible to distinguish between the grape curculio and the grape berry moth, since the grubs of the former are whitish and quite destitute of legs, whereas the larvæ of the berry moth have well-developed legs, are greenish in color, quite agile, and likely to escape quickly upon being disturbed. See figure 4, showing, at *a*, an injured berry; *c*, the egg-cavity and egg beneath skin of grape; and *d*, an infested berry cut open.

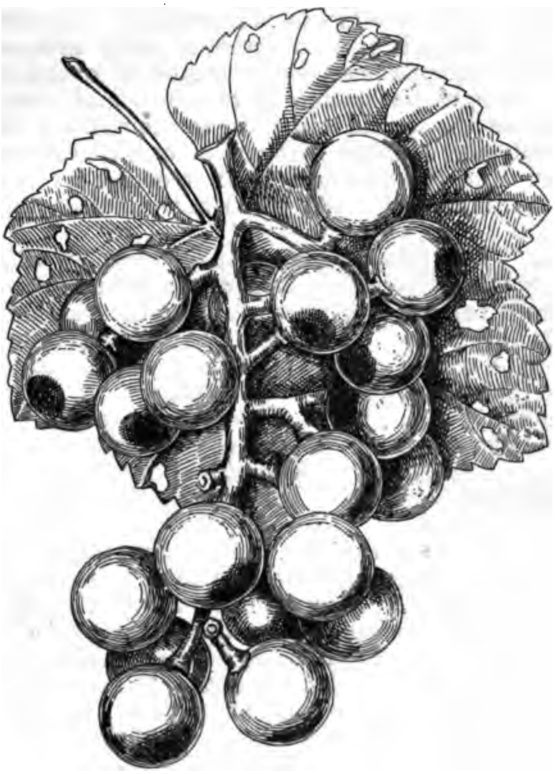


FIG. 3.—Grape leaf, showing feeding marks of grape curculio beetles, and bunch of grapes infested with larvæ. Somewhat reduced.

Distribution and Destructiveness.

The grape curculio is a native species, feeding originally on the wild grape, as it does at the present time. It has been recorded from Arkansas, Missouri, Tennessee, Kentucky, Illinois, Minnesota, Ohio, New Jersey, West Virginia, and North Carolina, and, according to Lintner, it probably occurs in New York State. The Bureau of Entomology has records of its occurrence in Pennsylvania, District of Columbia, West Virginia, North Carolina, and Nebraska. According to Le Conte and Horn, its distribution is "Middle, Southern, and Western States." The insect was described in 1830 by Thomas Say, but it first attracted attention as a grape pest in 1853 in the vicinity of Cincinnati, Ohio. An account of the species was given in 1867 by

B. D. Walsh, and comments were given on its injuries in Illinois, Ohio, and Kentucky. Injury by this species is more or less local and intermittent. Serious injury was reported by G. R. Wood in 1890 in the vicinity of Sandusky, and in 1891 Professor Webster found it very destructive in vineyards in Franklin County, Ark. For the past eight or ten years the grape curculio has been very destructive in many localities in West Virginia, destroying in many vineyards a large percentage of the crop. The species has been carefully studied by Mr. Fred E. Brooks, of the West Virginia Agricultural Experiment Station, and reported on in detail in Bulletin 100 of that institution. As shown by the experience in West Virginia and elsewhere, the species, under certain conditions, may become a very serious pest, ranking with the root-worm or berry moth. Mr. Brooks has shown that the insect is readily controlled with arsenical poisons and, as will be detailed later, (p. 47) treatments for the root-worm and berry moth will also keep this pest under control.

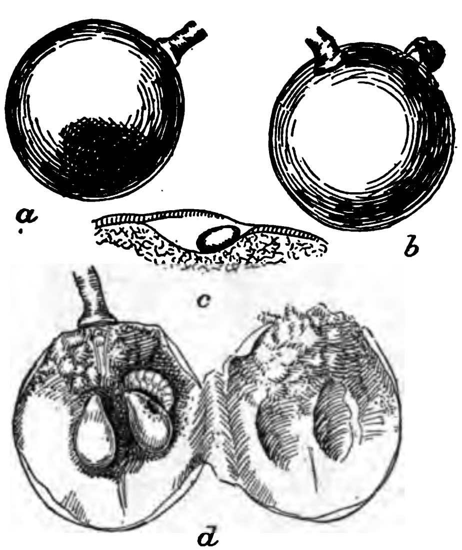


FIG. 4.—Work of grape curculio (*Craponius inæqualis*) in berry of grape: *a*, Berry from which grub or larva has emerged; *b*, adult or weevil ovipositing on berry; *c*, enlarged section of portion of berry, showing egg cavity and egg; *d*, injured berry, cut open and showing larva at work. *a*, *b*, *d*, Enlarged; *c*, highly magnified.

Life History and Habits.

The insect passes the winter in the adult or beetle stage, hiding under trash in and near vineyards, especially bordering woods. About the time in the spring that the grape is in bloom the beetles come from their hibernation quarters and for the first few days or a week are quite sluggish, but gradually become more active, feeding on the foliage of the grape until the berries are about one-fourth grown or of sufficient size to be suitable for receiving the eggs—according to Mr. Brooks, in 1905, covering a period of about 25 days. This habit of feeding on the exposed portions of the vines some 3 to 4 weeks before egg-laying permits of their ready destruction by arsenical poisons. Late in June, in the latitude of West Virginia, the females begin depositing eggs in the berries, excavating a cavity in which a single egg is placed. About 4 to 6 days, varying with the temperature, are required for the eggs to hatch, and the resulting larva burrows through the pulp, reaching the seed in 3 or 4 days, which is penetrated and the contents devoured. In 12 to 15 days the larva has become full grown and leaves the berry by eating a hole to the outside, falls to the ground and at once seeks a suitable place for pupation, as under stones, lumps of earth, or just below the surface of the soil. Here an earthen cell is made and the larva transforms to the pupa, the adult beetle emerging in the course of 18 or 19 days, at first blackish in color with gray hairs, but soon becoming the normal brown color. In figure 5 the parent beetle is shown in dorsal view at *a*, and a side view at *c*; the larva or grub is shown in dorsal and ventral views at *d* and *e*, and the pupa at *f*.

The life cycle from egg to adult, as stated by Brooks for a large series of individuals, requires about 35 days. The new generation of beetles feed upon the foliage until fall, when they go into hibernation, appearing the following spring, as stated. Mr. Brooks determined the egg-laying capacity of 30 beetles, the minimum number deposited by one insect being 63, and the maximum 392, with an average of about 257, the oviposition period extending from June 22 to September 10, a period of 81 days. Oviposition is apparently most active during the first one or two weeks of July. The beetles of the hibernating and of the new generation overlap, and the earlier-appearing individuals of the latter may oviposit, but the resulting larvæ will mostly fail to reach maturity. Practically there is but one generation a year in the latitude of West Virginia, while in the South a second generation may occur, though it is considered doubtful.

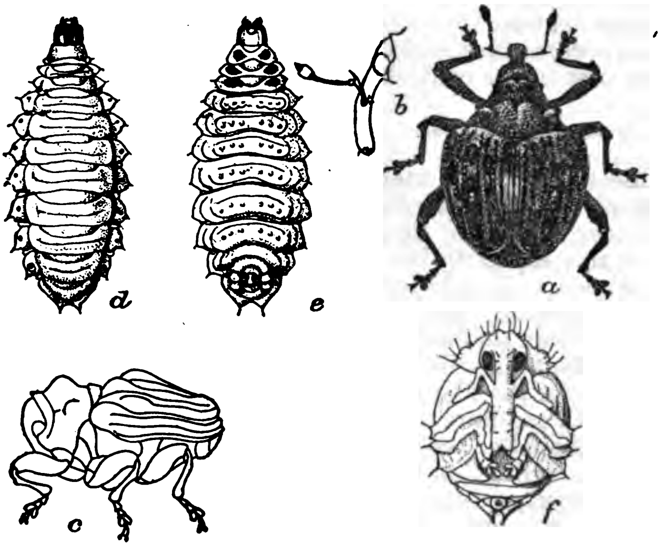


FIG. 5.—Grape curculio (*Craponius inæqualis*): *a*, Adult or beetle, from above; *b*, head, antenna, and beak of same, from side; *c*, adult, from side; *d*, larva, from above; *e*, same, from below; *f*, pupa, from below. All much enlarged.

Treatment.

Poisoning.—The beetles feed freely upon the foliage of the grape in the spring for several weeks before egg-laying begins and continue feeding in the fall after egg-laying ceases along with beetles of the new generation, and it is thus an easy matter to bring about their destruction by arsenical sprays. The treatments advised for the grape berry moth and root-worm, with perhaps an additional treatment 2 or 3 weeks later, will practically control the insect.

Bagging.—Fruit may also be well protected by bagging the clusters soon after the grapes have set. as already mentioned in connection with the grape berry moth.

GRAPE LEAF-HOPPER.

Throughout the United States and Canada, wherever the grape is grown, this small leaf-hopper (*Typhlocyba comes* Say) will almost invariably be found in greater or less numbers infesting the lower surface of the leaf, where it feeds and breeds, increasing in numbers as the season progresses, until by late summer and fall the vines are often literally swarming with it. Throughout its extended range the insect may be quite destructive in some localities nearly every year, and is likely to become so elsewhere at any time. The grape leaf-hopper is an insidious pest, often not noticed by the vineyardist until late summer and fall, when the yellow and brown-blotched leaves, falling prematurely, attract attention, by which time the injury has been done. The insects in feeding extract large quantities of liquid food, sucking it out from the interior of the leaf by means of their tube-like mouth-parts. When they are abundant this constitutes a heavy drain on the vitality of the plant. The injury to and loss of leaves prevents the proper assimilation of food by the vines; the fruit may be materially reduced in quantity and will lack much in flavor and sugar content. Although the yearly loss to grape growers from the attack of this species is sufficient to place it among the first-class pests of the vine, but little effort ordinarily is made to control it, perhaps principally because no very practicable remedy has until recently been proposed. In the literature of the species there are many records of serious outbreaks of the pest here and there over the country, and recently the insect has attracted more than usual attention on account of serious injury in the Chautauqua and Erie grape belts, where it has been carefully studied by Professor Slingerland.[a]

Description and Life History.

The adult grape leaf-hopper is quite small, measuring not more than one-eighth of an inch in length. It is very agile, moving with almost equal facility in all directions, and flies out from the vines often in swarms upon slight disturbance. The general appearance of the insect is shown in figure 6, the back of the insect being marked with yellow or red, the exact pattern and color varying much among different individuals and according to season. There are numerous varieties of the insect based on these variations, several varieties often occurring together on the same vine, though more usually insects showing one type of color pattern will be found to predominate. The insect passes the winter in the adult condition in hibernation in trash in and near vineyards, in the edges of neighboring woods, in grass along gullies, in ditches, etc. Early in the spring the insects come from winter quarters and attack almost any succulent vegetation at hand. By the time the foliage of the grape appears they are out in large numbers and begin to infest the vineyards. These adult hoppers of the

---

[a] Bul. 215, Cornell Agrl. Exp. Station (1904).

hibernating generation feed and breed on the lower or earlier-appe
ing leaves, gradually disappearing as the season progresses, but
before some of their progeny have reached the adult condition. So
weeks are spent by the adults in the spring in feeding before e
laying begins. Eggs are placed just beneath the epidermis in
lower leaf surface, usually singly but also in groups of from 6 to 9,
egg stage, according to Professor Slingerland, lasting from 9 to
days. Egg-laying probably continues for two months or m
When just hatched the young hopper is very small, whitish in co
with red eyes, later becoming striped with yellow. In the cou
of their growth these nymphs molt four times, the white skins be
very numerous on the lower surfaces of badly infested leaves,
shown in figure 6, at *g*. The nymphs feed in the same man
as the parents, sucking juices from the leaves, at first on the lo
surface of the older leaves where they were born, but later spre
ing more or less generally over the plant. They are very ag

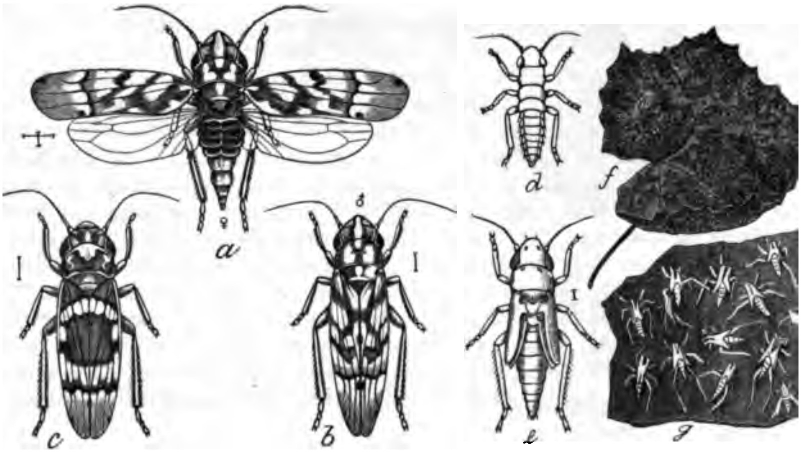


FIG. 6.—Grape leaf-hopper (*Typhlocyba comes*): *a*, Adult female; *b*, adult male; *c*, another for the species, showing variation in markings; *d*, newly-hatched nymph; *e*, last stage nymp appearance of injured leaf; *g*, cast pupa skins. *a-e*, Much enlarged; *g*, less enlarged; *f*, red (From Marlatt.)

running in all directions, but do not leap or hop. In New York St
Professor Slingerland found that [illegible]rom 30 to 35 days were requi
[illegible] heir development in summe[illegible] o the adult, and that there is
[illegible] ull generation and a partia[illegible] nd brood [illegible] nymphs each y
[illegible] ndividuals of this partia [illegible] robably not matur
[illegible] parts [illegible] wo full generation
[illegible] lle [illegible] is to be the case
[illegible] late summer
[illegible] tages are to be fo
[illegible] ing is very appar
[illegible] the older ones m
[illegible] the approach of
[illegible] hibernation quarters

Remedial Measures.

The grape leaf-hopper has proved to be a difficult pest to combat successfully. Various practices have been proposed, such as the use of trap lanterns to burn at night, the raking and burning during winter of fallen leaves and trash in vineyards, the use of sticky shields or fans to catch the adults as they fly from the vine on being disturbed, and in California the use of insect nets for the same purpose.

Extensive field experiments were made by Professor Slingerland and his assistants in 1902 in Chautauqua vineyards against this pest, and fully recorded in Bulletin 215 already cited. He found that large numbers of the hibernated adults could be caught on sticky shields carried along each side of the row, the insects being frightened out by disturbing the vines. This work is done early in the season, before oviposition takes place to any extent. A light wooden frame is made, 7 or 8 feet long by 4 feet high. To the crosspiece at the bottom, which should be up from the ground about a foot, are fastened several stiff wires of the shape of a hayrake tooth. These are fastened so that the points curve inward and downward to the ground at base of plants when the shield is held in place beside the vines. The whole framework, including the wires, is covered with oilcloth which is coated with a sticky substance, made by using melted resin, 1 quart, and castor oil, 1 pint.

Early in the season the insects will be found mostly on the lower leaves and the frame need not be high. As the higher leaves are invaded the height of the frame must be increased. In controlling the insects in this way it is very important to catch the over-wintering adults before egg laying has begun, thus greatly reducing the number of progeny to appear later, and the operation of catching the insects must be repeated at frequent intervals.

Extensive tests with sprays were also made, and it was found practicable to destroy the young wingless hoppers or nymphs with a whale-oil soap solution, the soap being used at the rate of 1 pound to 10 gallons of water. The spraying must be done very thoroughly, covering the under surface of the leaves, as only those nymphs are killed which are actually hit with the spray. This work should be begun when it is observed that the young are becoming common. In the Chautauqua and Erie grape belts this will be early in July. There will be less foliage to treat at this time than if the work be deferred until somewhat later. Repeated applications may be necessary, especially if the work is not thoroughly done. It has been noted by Mr. Fred Johnson, of this Bureau, that whale-oil soap leaves a stain on the fruit at picking time, greatly lessening its market value for dessert purposes. It is likely that an 8 to 10 per cent kerosene emulsion could be used, which would obviate this difficulty, and would prove equally effective in killing the young hoppers.

Thorough cleaning up of fallen leaves and trash in vineyards during the winter will undoubtedly destroy many hibernating adults, and if this work be extended to adjacent areas where the insects are likely to find shelter, the reduction in their numbers will be materially greater. Where practicable the burning over of adjacent meadows, wood lots, and spaces along fences is very advisable. It has been observed that in vineyards in which clean culture is practiced, all grass and weeds being kept down throughout the season, the "hoppers" are notably less abundant than where this practice is not followed. The absence of suitable hibernation quarters in the vineyard causes them, largely, to migrate elsewhere, and vineyards receiving such care are much less seriously infested the following spring and summer.

The grape leaf-hopper secures its food by sucking juices from the interior of the leaf, and arsenical poisons useful against the grape rootworm and the grape berry moth are quite useless against this pest.

GRAPE LEAF-FOLDER.

Observing grape growers have often noticed, especially during midsummer and later, grape leaves folded together, the interior (upper) surface of the leaf being more or less skeletonized, and within the fold a slender larva, which, upon being disturbed, is apt to wriggle out and fall or hang suspended by a thread. This insect, the grape leaf-folder (*Desmia funeralis* Hübner; see fig. 7), is widely distributed and a few are to be found in vineyards almost every year, while here and there throughout their range they may be so abundant as to do serious injury. There are two broods each year in the more northern States and three or possibly more in the South. The insect winters in the pupal stage in the folded and fallen leaves, the moths appearing in the spring shortly after the foliage puts out, and the eggs are placed in small patches here and there on the vine. Upon hatching, the young larvæ attack the foliage, folding the leaves as stated. Mr. Johnson has observed that larvæ of the first brood may attack bunches of grape blossoms and young fruit in a way similar to the grape berry moth. In 3 or 4 weeks the larvæ are full grown and transform to pupæ within the folded leaves, moths emerging some 8 or 10 days later. By midsummer and fall the insects may become quite abundant, and in badly infested vineyards the folded leaves are everywhere in evidence and are quite conspicuous from the color of the lower surface. In the fall the larvæ pupate in the folded leaves and pass the winter in these on the ground.

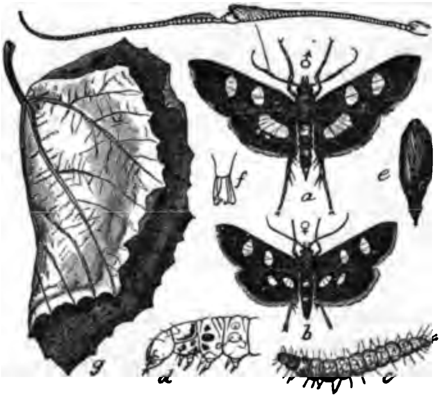


FIG. 7.—Grape leaf-folder (*Desmia funeralis*): *a*, Male moth and enlarged antenna of same; *b*, female moth; *c*, larva; *d*, head and thoracic segments of same, enlarged; *e*, pupa; *f*, tip of pupa, enlarged; *g*, grape leaf folded by larva. (From Marlatt.)

Treatment.

Where the insects are but moderately abundant it will be quite practicable to search out the folded leaves and crush between the hands the larvæ or pupæ within. The destruction of the first brood in this way would greatly reduce the number of the insects later in the season.

Vines sprayed with arsenicals for the root-worm and the berry moth will be well protected from the leaf-folder, for in this way the majority of the leaves will be sufficiently poisoned to insure the destruction of the larvæ and prevent the folding of the leaves. After a leaf has been folded the larva is practically safe from poisoning. As the winter is spent in the pupal stage in the leaves on the ground, many of the insects may be destroyed by collecting and burning the fallen leaves, as recommended in the case of thé grape berry moth and the leaf-hopper.

GRAPEVINE FLEA-BEETLE.

Early in spring, as the buds of the grape begin to swell and burst, these may be scooped out or entirely consumed by a small blue or greenish beetle (*Haltica chalybea* Illiger), measuring about one-fifth of an inch in length, of robust shape, with thick thighs, and jumping readily from the vines upon being disturbed (see fig. 8). When the beetles are abundant all of the buds on the vines may be quite destroyed, greatly retarding leafing out or even causing the death of the plant. Later the young foliage is eaten by the beetles, the females depositing their eggs more or less on the leaves, but largely, according to Slingerland,[a] in cracks in the bark at base of buds, between bud scales, or even in the holes which have been eaten into the buds. The resulting larvæ feed on the leaves of the grape, mostly on the upper surface, and are thus readily destroyed with sprays. In 3 or 4 weeks the grubs have attained full growth; then, dropping to the ground, they make an earthen cell an inch or so below the surface, and transform to pupæ, from which the adult beetles will emerge in the course of 1 or 2 weeks. The new brood of beetles feeds upon the grape and other plants, going into hibernation in the fall and appearing the next

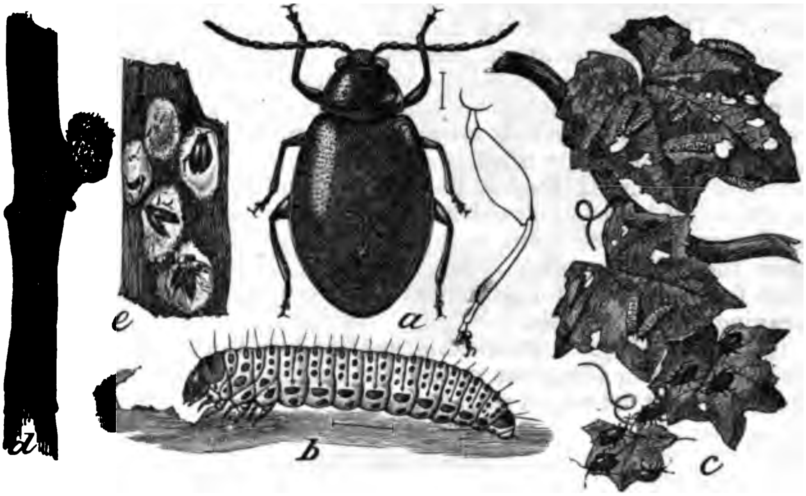


FIG. 8.—Grapevine flea-beetle (*Haltica chalybea*): *a*, Adult or beetle, with more enlarged leg at right; *b*, larva; *c*, larvæ and beetles on foliage; *d*, injury to buds; *e*, beetles killed by fungus. *a*, *b*, Much enlarged; *c*, *d*, *e*, about natural size. (From Marlatt.)

---

[a] Bul. 157, Cornell Univ. Agrl. Exp. Station (1898).

spring to attack the buds of the grape, as stated. In the Northern States Slingerland's studies have shown but one generation of the insect each year. In the South two or more generations annually are supposed to occur, but definite evidence on this point is wanting.

The flea-beetle is native to North America, and occurs very generally throughout the eastern half of the United States, its western limits being Minnesota, eastern Nebraska, Kansas, and Texas. Its natural food is undoubtedly the wild grape, though numerous other plants are fed upon, as plum, apple, pear, quince, blue or water beech (Carpinus), elm, etc.

Treatment.

In vineyards which are regularly sprayed with arsenicals and Bordeaux mixture the flea-beetle will be effectively kept in check. The first application for the berry moth before the blossoms open, together with the application made after the blossoms fall, will destroy the larvæ, since these feed almost exclusively on the upper surface of the leaves. The insects thrive best in neglected vineyards, and may become quite abundant and destructive locally. Where it is desired to treat for this insect only, the vines should be thoroughly sprayed with an arsenical just as the buds are beginning to swell, or somewhat earlier. A close lookout must be kept for the first signs of the beetles, and the poison must be applied immediately. The delay of a day or so may mean the loss of the buds, and hence of the fruit crop. In the small home vineyard it will be practicable to search out the beetles and remove them by hand, doing the work in the morning when they are less agile. As stated, the destruction of the larvæ when feeding on the foliage later will be very easily accomplished by spraying with arsenicals.

It will also be quite practicable, as stated by Doctor Howard, to jar the beetles from the vines on canvas frames placed beneath, which should be kept saturated with kerosene.

ROSE-CHAFER.

About the time of blooming of the grape in the spring the rose-chafer (*Macrodactylus subspinosus* Fabricius) may suddenly put in an appearance, often in enormous numbers, the long, spiny-legged, awkward, brownish beetles literally covering the plants, feeding at first upon the blossoms, but later attacking the young fruit and foliage, [illegible] eaten bare except [illegible] veins (see fig. 9). This [illegible] general feeder [illegible] practically all fruits—e. g., [illegible] berries, peaches [illegible] various vegetables, [illegible] many [illegible] Spiræa, Deut- [illegible] ast-mentioned [illegible] fer" or "rose- [illegible] y complained of from [illegible] When abundant, the beetles [illegible] destroying the blossom [illegible] ly devoured are [illegible] misshapen and crack [illegible] 3 or 4 weeks of feeding [illegible] as they came.

The rose-chafer is rather widely distributed, occurring from Canada south to Virginia and Tennessee and west to Colorado. It is recorded also from Oklahoma and Texas, though west of the Mississippi it is apparently not very injurious. In the New England and Central States it is more abundant, and is most troublesome perhaps in New York, Pennsylvania, New Jersey, Delaware, Maryland, Virginia, and Ohio, large outbreaks in ruinous numbers occurring more or less locally where the soil is light and sandy.

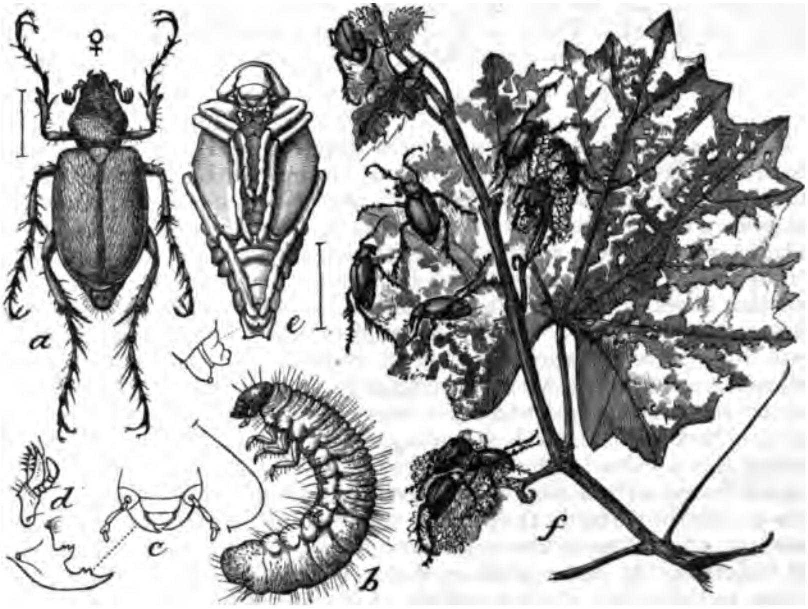


FIG. 9.—Rose-chafer (*Macrodactylus subspinosus*): *a*, Adult or beetle; *b*, larva; *c*, *d*, mouth parts of same; *e*, pupa; *f*, injury to leaves and blossoms of grape, with beetles at work. *a*, *b*, *e*, Much enlarged; *c*, *d*, more enlarged; *f*, somewhat reduced. (From Marlatt.)

Breeding Grounds.

The insect lives in the larval stage underground, feeding on the roots of various plants, especially on the roots of grasses. Doctor J. B. Smith found larvæ in abundance in a vineyard in New Jersey and in a blackberry patch, feeding apparently on the roots of grasses and weeds which grew sparsely between the rows, and larvæ were still more numerous under the sod bordering the vineyard. In an adjacent meadow, where the soil was heavier and less sandy, no larvæ could be found. In general, the insects breed principally in light sandy soils, especially in meadow lands, but also in other places where there is more or less of growth of grass and weeds, and, to a less extent, in cultivated ground. Wet, clayey, or compact soils do not furnish desired conditions for the insects, and from the fact that they are largely confined to the lighter soils it becomes practicable to reduce them greatly by planting these to annual crops which receive thorough cultivation.

Life History.

The beetles deposit their eggs singly, burrowing beneath the sc laying, according to Doctor Smith,[a] from 12 to 20 eggs. The resu ing larvæ feed upon the roots of various grasses and possibly wee and other vegetation. They are mostly full grown by fall, a burrow below the frost line, where the winter is spent. With t coming of spring the grubs ascend toward the surface and enter t pupa stage, from which in from 10 to 30 days, varying with t temperature, the beetles develop and attack the grape and otl plants, as stated. There is thus but one generation each year, t principal injury of the insect being done during the 3 or 4 weeks its life as a beetle.

Treatment.

The rose-chafer is an exceedingly difficult insect to combat sı cessfully. When the insect occurs only in moderate numbers, arse cals will be reasonably satisfactory; but when it occurs in swarı the plants are reinfested as fast as the insects are killed. It is p sible, however, that a heavy application of arsenate of lead, say 5 t pounds to 50 gallons of water or Bordeaux mixture, will largely p tect the vines, and this plan should be tested by vineyardists cc fronted with this pest. Very thorough applications should be ma upon first signs of the insects and repeated as necessary. Ma different substances have been applied to vines to render them obn ious to the beetles, but none of these has proved to have any spec value. Perhaps the method most generally relied upon is picking jarring the beetles from the vines. In the latter work an umbrel shaped frame with a canvas or oil cloth covering, with a can of ke sene at the bottom, is frequently used, being held under the vin which at the moment are sufficiently shaken to cause the beetles fall. Jarring or hand-picking must be done every morning, better, twice a day, during periods of severe infestation.

The numbers of this insect may be considerably lessened by stricting its breeding grounds. In vineyards on sandy or light s especial care should be taken to keep the rows and surroundings f from weeds and grass, upon the roots of which the larvæ feed. San meadow lands in the vicinity of vineyards should be broken up a cultivated to annual crops, and in this work the cooperation of vi yardists throughout a neighborhood is especially important.

Bagging grapes as soon as the fruit has set is often practiced, a affords protection not only against further injury from the ro chafer, but also from the grape berry moth, the grape curculio, a fungous diseases of the fruit.

INSECTICIDES.[b]

ARSENICALS.

Arsenicals, applied in the form of a spray, are effective agai the grape root-worm, the grape berry moth, the grape curcu the grape leaf-folder, and other insects which devour the foli and fruit. The arsenical is best used as an ingredient added to the Bordeaux mixture, which is the standard remedy for the control of fungous diseases. When an arsenical is used simply in water the vineyardist should always add, to each 50 gallons of the liquid, the milk of lime made from slaking 2 to 3 pounds of good stone lime.

---

[a] Bul. 82, N. J. Agrl. Exp. Station (1891).

[b] For a more extended account of insecticides, see Farmers' Bulletin 127, U Dept. of Agriculture, by C. L. Marlatt.

Paris green.—This is used at the rate of 1 pound to each 100 or 150 gallons of liquid, whether water and milk of lime or the Bordeaux mixture. Paris green should be worked into a paste with water before being added to the liquid in the spray tank, to prevent its adhering in small lumps. When used with Bordeaux mixture, the latter will probably serve to hold it well on the vines, giving results perhaps equal to those produced by arsenate of lead.

Scheele's green.—This arsenical is similar to Paris green, being the simple arsenite of copper containing no acetic acid, and hence considerably cheaper. It is a much finer powder than Paris green and remains in suspension longer. It is used in the same way and at the same strength recommended for the former poison.

Arsenate of lead.—There are now numerous brands of arsenate of lead on the market, and vineyardists should be careful to buy an efficient and safe kind. Some preparations sold as arsenate of lead contain an amount of free arsenic dangerous to foliage, and an unnecessary amount of water may also be present, thus lowering the quantity of poison when used at a given strength. A proper arsenate of lead should contain no free arsenic and should have as much as 50 per cent actual arsenate of lead. Arsenate of lead is used at the rate of 3 to 6 pounds to each 50 gallons of liquid, and, as it comes in the form of a putty-like paste, must be worked free in a little water in a bucket or other suitable vessel before it is added to the spray tank. It may be used much stronger than any other arsenical and it adheres well to the foliage. For these reasons it is preferred by many vineyardists.

Arsenite of lime.—This is much the cheapest of the arsenical poisons. On apple it is stated to be very satisfactory, and it should be equally so on grape. It seems not yet to have been used to any extent on grape, and should be tried first in a small way. It may be prepared at home according to the following formula:

White arsenic	pounds	1
Sal soda crystals	do	4
Water	gallon	1

All of the ingredients are boiled together for a few minutes or until dissolved, and any water lost by evaporation should be restored. This constitutes a stock solution, 1 pint being used with each 40 or 50 gallons of Bordeaux mixture. When it is used in water the vineyardist must add the milk of lime made from slaking 2 to 3 pounds of good stone lime, which is necessary to produce the arsenite of lime.

CONTACT REMEDIES.

For insects which secure their food by sucking the juices from the plant, such as the grape leaf-hopper and aphides, contact insecticides must be used. Two such insecticides are whale-oil soap solution and kerosene emulsion. These preparations are not ordinarily used in Bordeaux mixture. They are sprayed on the vines in the usual way.

Whale-oil soap.—For vines in foliage, whale-oil soap is used at the rate of 1 pound to 8 or 10 gallons of water. There are several grades of this article on the market, but a potash whale-oil soap is best, especially one that does not contain more than 30 per cent of water.

Kerosene emulsion.—This doubtless will be equally satisfactory as a spray against the grape leaf-hopper, and may be prepared as follows:

Whale-oil or other soap	pounds..	2½
Kerosene (150 flash test)	gallons..	5
Water to make	do....	50

The soap is dissolved in 6 to 8 gallons of hot water, and the kerosene is at once added. The whole is then thoroughly emulsified by the use of a hand pump, pumping the liquid back upon itself for 8 or 10 minutes or until a creamy-white emulsion results. This, when diluted with the required amount of water, will contain 10 per cent of kerosene, which strength should be effective in destroying young hoppers without injuring the foliage or the fruit. If a smaller quantity of emulsion than 50 gallons is desired, it may be made, simply observing the proportions given.

FUNGOUS DISEASES.

The fungous parasites of the American varieties of grape are indigenous, and came originally from the native wild vines. With the gradual extension and development of the grape-growing industry there has also been an increase in the distribution and destructiveness of these fungous diseases. The conditions which necessarily obtain in commercial grape culture have disturbed the equilibrium which had become established between the vine and its parasites in their wild state, and have facilitated the production and distribution of the diseases. In the selection and breeding of the grape attention has been devoted chiefly to the improvement of the fruit, and this has apparently resulted in a decrease of the natural powers of resistance to disease originally possessed by the wild vines.

In certain sections of the country where grape growing was once a profitable industry it has largely been abandoned, chiefly on account of the great loss caused by disease. The amount of loss from fungous diseases of the grape in the eastern half of the United States during the past season (1906) is estimated at from 15 to 20 per cent of the entire crop. In some localities it reached 40 to 50 per cent, and in some particular vineyards where there was promise of a crop of 4 or 5 tons per acre the loss was total, while in one favored region the loss was not over 5 per cent.

Injury due to fungi depends largely upon weather conditions. The conditions most favorable for the development of the majority of the fungous diseases are excessive moisture and heat. The general physiological condition of the vines is also important. Vines which are kept thrifty and vigorous by proper care and cultivation are not likely to suffer so severely from most diseases as those which are neglected.

The principal fungous diseases in the order of their importance are black-rot, downy mildew, powdery mildew, anthracnose, and ripe-rot. There are also other diseases, which will be referred to later, but they are either not of sufficient importance to deserve much attention here or else their treatment is not yet satisfactorily determined.

BLACK-ROT.

Black-rot is the most generally distributed and destructive fungous disease of the grape in the region east of the Rocky Mountains. It is caused by a parasitic fungus known as *Guignardia bidwellii* (Ell.) V. & R. It gains entrance to the plant by means of minute germs called spores. These are borne in small black spore cases, and can not be seen with the naked eye. They are distributed chiefly by the wind and rain. Two or more forms of spores are produced, as shown in the accompanying illustration (fig. 10, *b*). When these spores come in contact with the young and tender parts of the vine, under favorable conditions, they germinate and produce a slender tube, which penetrates the tissue and may destroy it.

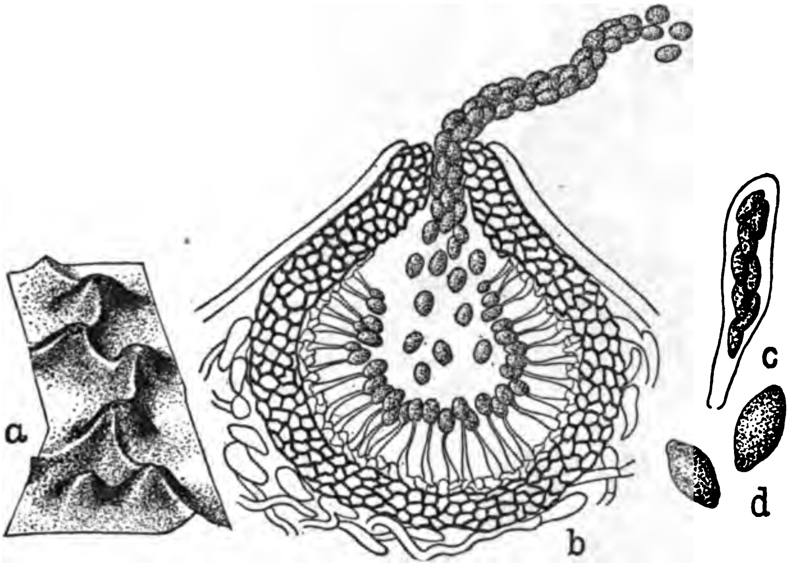


FIG. 10.—The black-rot fungus (*Guignardia bidwellii*): *a*, A portion of an affected grape, showing the pustules in which the spores are produced (slightly magnified); *b* a section of one of these pustules very highly magnified, showing the manner in which the summer spores are produced and discharged; *c*, a sac containing winter spores; *d*, single winter spores very highly magnified.

This disease attacks the leaves and shoots, as well as the fruit. It usually makes its first appearance on the leaves and young shoots, producing reddish-brown dead spots. The fruit may be attacked when young, but usually the disease does not attract attention until the berries are half grown or more. Brown or blackish spots first appear; these spread and soon affect the whole berry, which becomes black and shriveled, as shown in the accompanying illustration (fig. 11). These diseased berries remain attached to the vine, and their surfaces become covered with minute black pustules, which contain the summer spores of the fungus. During the winter and spring another form, called the winter, or resting spore, is produced upon these old, shriveled berries (fig. 10, *c*, *d*). These spores help to carry the disease over from one season to another. This fact would indicate the desirability of destroying, by burning, all diseased fruit, as well as leaves and prunings, as early in the spring as possible.

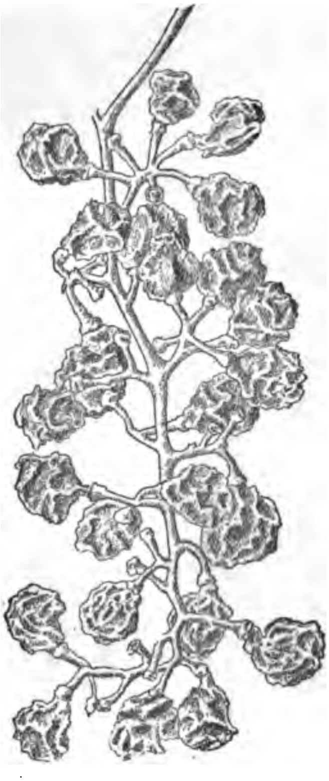


FIG. 11.—A bunch of grapes destroyed by black-rot.

Treatment.

This disease can be effectually controlled by thorough spraying with Bordeaux mixture. Five or six applications are usually necessary during the season, the first being made just before the buds open. For the last one or two applications, some fungicide which does not stain the fruit should be used. Burgundy mixture is recommended for this purpose. Full directions regarding the preparation of the fungicides and the times of application will be found later.

Covering the bunches of grapes with paper bags soon after the blossoms fall is a means of preventing black-rot and most other fungous parasites. It is usually regarded as too laborious and expensive for large vineyards, but may be profitably practiced where only a small number of vines are grown.

DOWNY MILDEW.

Downy mildew (*Plasmopara viticola* (B. & C.) Berl. & De Toni) in certain seasons and in northern localities sometimes causes more loss than black-rot and is a close rival for first place among the fungous enemies of the grape. It attacks all the tender growing parts of the vine. Usually it is at first most noticeable on the foliage, producing greenish yellow, irregular spots upon the upper surface, which become reddish brown. At the same time there appears on the under surface of the leaf a thin, loose, white, downy growth, suggestive of hoar frost (fig. 12). This growth consists of the fertile fungous filaments bearing the summer spores (fig. 13, *a*, *b*), which under favorable conditions are distributed by the wind and water to the berries and other parts, where they germinate, penetrate the tissues, and continue their destructive work. The young shoots are also frequently attacked and killed.

The fruit, if attacked when young or only partly grown, shows first a brownish spot, and later becomes covered with the gray, downy growth of the fungus. This form of the disease is sometimes called "gray-rot" by vineyardists (fig. 14). When the berries escape the disease until they are half grown or more it appears as a brownish or brownish purple spot which spreads and soon involves the whole berry. The affected fruit becomes soft and wrinkled and falls to the ground when disturbed. This stage of the disease is sometimes called "brown-rot."

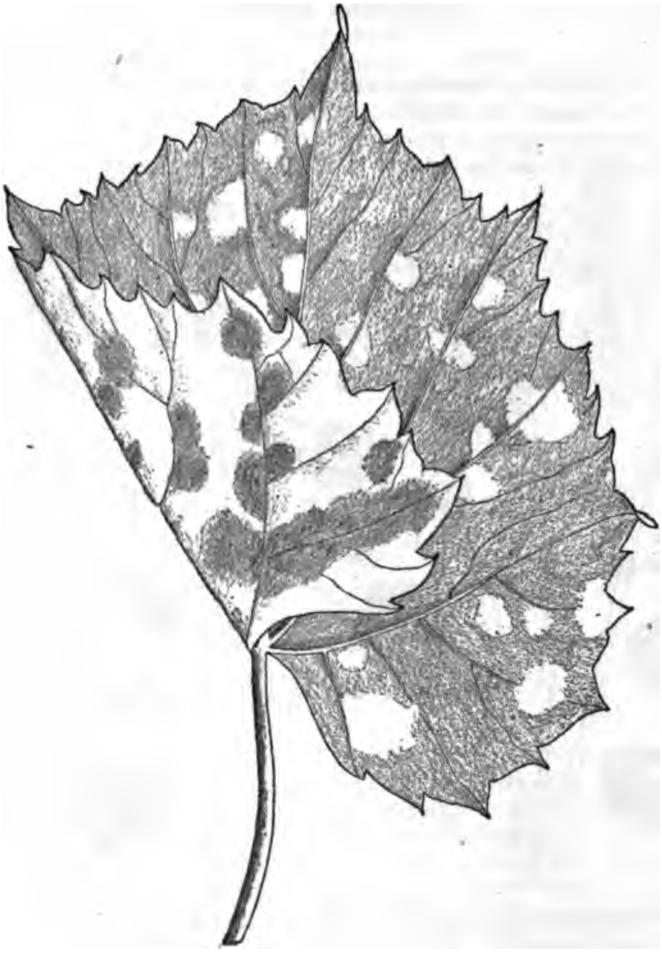


FIG. 12.—A grape leaf attacked by the downy mildew (*Plasmopara viticola*), showing the appearance of the leaf above and below.

Besides the summer spores mentioned, there is also produced within the diseased tissues another form of reproductive body, sometimes called a winter, or resting, spore (fig. 13, *c*). These spores are produced in much smaller numbers than the summer spores and are provided with a rather thick, dark-colored outer covering apparently intended for their protection during the winter.

This disease, like the black-rot and many others, develops most rapidly and does most injury during hot, wet weather.

Treatment.

It is desirable to destroy as many as possible of the diseased leaves, shoots, and berries, which may contain the winter spores. Thorough spraying, as recommended for the black-rot, will effectually control this disease.

POWDERY MILDEW.

The powdery mildew (*Uncinula necator* (Schw.) Burr.) rarely causes great loss to American varieties of grapes. It is most severe on the European, or vinifera, grapes. This mildew belongs to a group of fungi quite different from the downy mildew. It differs from all other parasites which attack the grape in its superficial habit of growth. The filaments of the fungus do not invade the tissues of the plant to destroy them. The parasite obtains its nutriment by means of sucker-like organs which penetrate the cell walls of the surface layer of tissue only. The fine, white filaments of the fungus, which constitute the vegetative portion of the parasite,

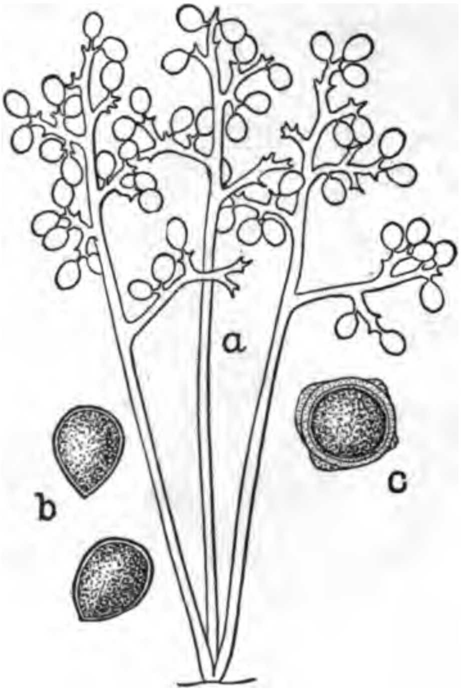


FIG. 13.—The fungus causing downy mildew: *a*, Fertile filaments of the downy mildew fungus, showing the manner in which the summer spores are borne; *b*, two summer spores; *c*, a winter, or resting, spore. (All highly magnified.)

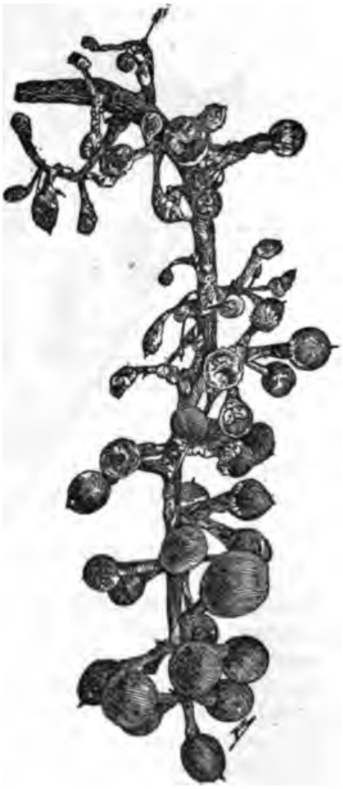


FIG. 14.—A bunch of young grapes partially destroyed by "gray-rot." This is a form of the downy mildew affecting the very young fruit.

spread over the surface of the leaves, shoots, and fruit, and send up short, irregular branches upon which immense numbers of summer spores are produced in short chains (fig. 15, *a*). These are most noticeable upon the upper surface of the leaf, giving it a fine gray, powdery, or mealy appearance. Finally the affected part of the leaf becomes light brown, and if the disease be severe the leaves fall. The fungus produces a similar appearance upon the young shoots. Berries which are attacked take on a gray, scurfy appearance, become specked with brown, and fail to develop further. Affected grapes when nearly half grown sometimes burst open on one side, exposing the seeds. The fruit does not become softened and shrunken as when attacked by the downy mildew.

Besides the summer spores, winter, or resting; spores are also produced in the latter part of the season. These are borne in sacs which are inclosed in minute black, globose fruiting bodies furnished with slender appendages curled at their tips (fig. 15, *b*, *c*, *d*). These black spore cases are so small that they can scarcely be seen with the naked eye, but by the aid of a hand lens they can be easily observed. The powdery mildew is usually more prevalent during dry, hot seasons than in wet ones. It differs in this respect from most of the other grape diseases. In California this is the principal fungous disease of the grape.

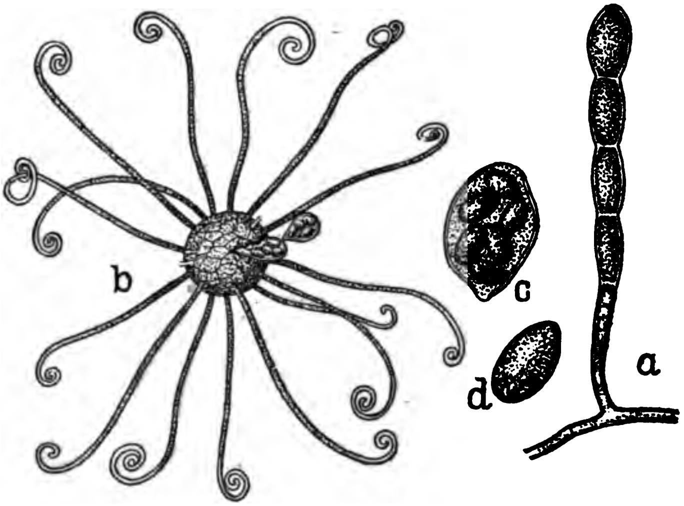


FIG. 15.—The fungus causing powdery mildew (*Uncinula necator*): *a*, A fertile filament of the fungus bearing a chain of summer spores; *b*, a spore case, in which the winter or resting spores are produced; *c*, a single sac containing winter spores; *d*, a single winter spore. (All highly magnified.)

Treatment.

Bordeaux mixture, as recommended for the black-rot, will prevent this disease. Where this trouble alone is to be combated it may be successfully done by dusting with flowers of sulphur. East of the Rocky Mountains, however, it should be treated with Bordeaux mixture, as it is rarely likely to occur alone.

ANTHRACNOSE.

Anthracnose (*Sphaceloma ampelinum* De By.) has also been called "bird's-eye rot," on account of the peculiar spots it produces upon affected grapes. Like most of the other diseases of the grape, it attacks the leaves and shoots as well as the fruit. On the leaves it at first appears as minute, irregular, dark brown, slightly sunken spots, having a darker margin. These spots usually become lighter colored when old, and frequently crack or fall out, leaving irregular holes in the leaves. This disease presents much the same appearance on the shoots as on the leaves, though the spots are frequently larger and more sunken (fig. 16). They also tend to run together and form irregular patches.

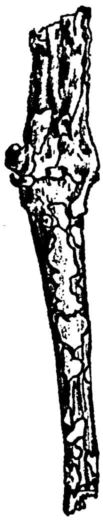


FIG. 16.- Grape shoot, showing spots produced by anthracnose (*Sphaceloma ampelinum*).

The disease is most characteristic and conspicuous upon the fruit. The spots are usually brown at first and surrounded by a narrow, dark purplish margin; they increase in size and gradually become grayish white and somewhat sunken. Frequently two or more spots unite and cover a considerable part of the berry (fig. 17). The affected tissues do not become softened, as in the case of the downy mildew, but the fruit becomes hard and more or less wrinkled. If only a small part of the berry is affected it may continue to grow, causing the diseased area to rupture and the seeds to become exposed. The bursting of the berries and the exposure of the seeds may, however, be produced by other causes, such as the powdery mildew and certain physiological disturbances.

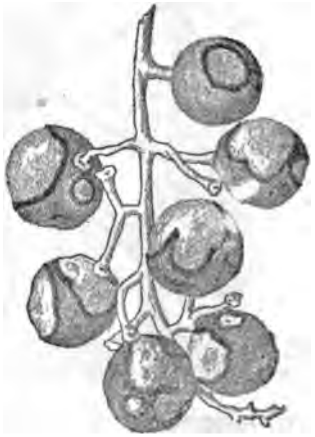


FIG. 17.—Portion of a bunch of grapes, showing the effect of anthracnose.

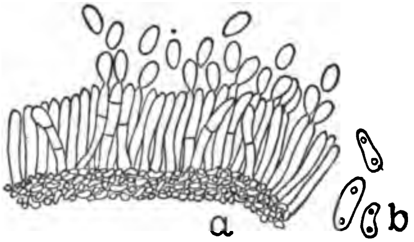


FIG. 18.—Section of an anthracnose spot, highly magnified: *a*, Showing the way in which the spores are borne; *b*, three of these spores more highly magnified.

On the diseased areas the minute spores or germs of the fungus are frequently produced in immense numbers. The way in which these spores are borne is shown in figure 18. No special winter form of spore is known to be produced by this fungus. The fine, thread-like filaments which constitute the vegetative part of the parasite live during the winter in the tissues of the vines and are ready for active growth in the spring.

The anthracnose is quite widely distributed in this country, but fortunately has not caused any great general loss. It should be carefully watched, however, as, when once well established under favorable conditions, its eradication is very difficult.

Certain varieties, such as Diamond, Brighton, Agawam, and Salem, are especially susceptible to this disease.

Treatment.

All diseased shoots should be cut and burned, as it is believed that it is through these that the disease is chiefly transmitted each season. Spraying with Bordeaux mixture, as recommended for black-rot, when accompanied by thorough cutting and burning of diseased parts, is likely to prove sufficient, except where the disease is unusually severe, in which case the treatment which has been adopted and found very successful in Europe may be followed. This consists of the application of the following mixture:

Sulphate of iron (copperas) ....pounds..	110
Sulphuric acid, commercial......quart..	1
Hot water.....................gallons..	26

First pour the acid upon the copperas and then add the water. This mixture should be prepared and handled with great care, as it is exceedingly caustic and will injure the skin, clothing, and almost everything with which it comes in contact. On this account it can not be applied with a common spray pump. A swab, made by attaching a bundle of rags to a stick, may be used in applying the mixture. All portions of the vines should be thoroughly covered with this preparation just before the buds begin to swell in the spring.

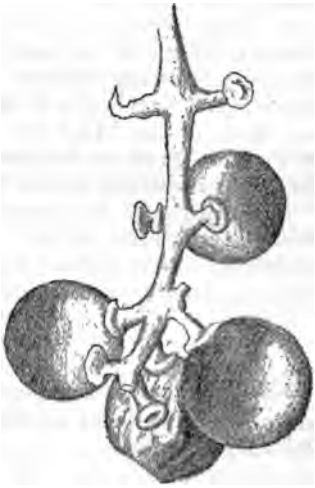


FIG. 19.—Grapes attacked by the ripe-rot (*Glomerella rufomaculans*).

RIPE-ROT.

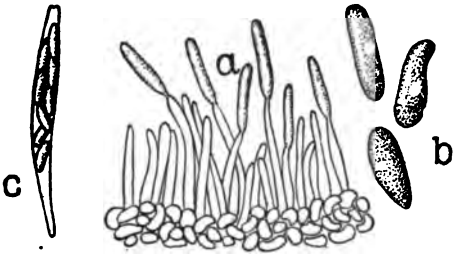


FIG. 20.—The fungus producing ripe-rot (*Glomerella rufomaculans*): *a*, Summer spores, showing the manner in which they are borne; *b*, the same spores, more highly magnified; *c*, a sac containing winter spores.

Ripe-rot (*Glomerella rufomaculans* (Berk.) Spauld. & von Schrenk) has also been called bitter-rot. The name bitter-rot is, however, applied to another fungous disease of the grape, caused by *Melanconium fuligineum*. As the present name indicates, the disease usually appears on the fruit when the latter is nearly mature, and under favorable conditions continues its development and destruction after the grapes are picked. It also attacks the leaves and stems, but is most noticeable and injurious on the fruit. The first indication of the disease is the appearance of reddish-brown discolored spots (fig. 19), which spread and finally extend over the whole fruit. The surface then becomes dotted with dark, slightly elevated pustules, in which the spores are borne (fig. 20, *a*, *b*.). At this stage of development this disease is not easily distinguished from the early stages of black-rot and bitter-rot. The berries do not shrivel up, however, as in the case of the black-rot, and usually are easily detached from the bunch. The spores mentioned are produced in large numbers and serve to spread the disease.

The fungus causing this disease is closely related to that which produces the bitter-rot of the apple, and by some is regarded as the same; but no entirely conclusive cross-infection experiments have yet been reported. The Department of Agriculture has demonstrated by means of pure cultures of this fungus that there is another stage, producing spores very similar in appearance to those just mentioned, but borne in sacs which are inclosed in spore cases similar to those of the black-rot fungus (fig. 20, *c*). This spore form is of very infrequent or doubtful occurrence in vineyards, and is probably not an important factor in the distribution of the disease.

It is difficult to determine how much injury is done by this disease on account of the liability of confusing it with other fungous troubles. It is quite generally distributed, and may cause more loss than is usually attributed to it.

Treatment.

Spraying as recommended for black-rot will largely prevent this disease. The later applications are especially important and should be very thorough.

LESS IMPORTANT DISEASES.

Bitter-Rot.

The bitter-rot of the grape is caused by a fungus known as *Melanconium fuligineum* (Scrib. & Viala) Cav. Fruit attacked by this disease presents an appearance quite similar to that produced by the ripe-rot. Bitter-rot is no doubt sometimes confused with other diseases. It is mostly restricted to the Southern States, and is not generally regarded as serious.

Treatment.—Spraying as for black-rot will probably prevent this disease.

White-Rot.

The effect of the disease known as white-rot (*Coniothyrium diplodiella* (Speg.) Sacc.) upon the fruit of the grape is somewhat similar to that of the brown-rot form of the downy mildew. It occurs in Missouri and the Southwest and has been reported as rather serious in some parts of Ohio.

Treatment.—There is nothing in the nature of this disease, so far as known, to indicate that it can not be satisfactorily controlled by the treatment recommended for black-rot. Sufficient knowledge of this subject to justify a positive statement in regard to treatment is not at present available.

Crown-Gall.

Crown-gall is a disease of somewhat uncertain origin, characterized by the formation of rough outgrowths, or excrescences, on the vines, usually near the surface of the soil. Certain forms at least are known to be contagious.

Treatment.—All plants bearing galls should be burned, and great care should be exercised to avoid planting diseased stock. Fungicides are apparently useless in combating this disease.

Root-Rot.

The roots of the grape are known to be attacked by several different fungi, especially when the root system has become weakened or injured by other causes. Two forms of root-rot are of sufficient importance to be mentioned here.

Vibrissea hypogæa.—The fungus known as *Vibrissea hypogæa* Ch. Richon & Le Monnier is usually associated with insect injury, caused either by Phylloxera or by the grape root-worm. It has been found in New York, Pennsylvania, and Missouri, and appears to hasten the death of plants, especially those on which the root-worm has been at work.

Treatment.—This root-rot can be prevented only by the destruction of the insects which injure the root system and thus give the fungus opportunity to gain a foothold.

Ozonium.—There is a root-rot of a more serious nature prevalent in and chiefly restricted to Texas and New Mexico. This is caused by a fungus known as Ozonium, which also attacks the roots of cotton and a great variety of other plants. It is most destructive in the black waxy, clay soils, which are very poorly aerated. Plants attacked die suddenly, the leaves and fruit withering up in a day or two and remaining on the vines.

Treatment.—No remedy is known for this root-rot of the grape. Soil upon which other plants have died with the same disease should be carefully avoided in planting vines.

Shelling.

The shelling or dropping of grapes from the bunches before maturity may be due to various causes. In some localities in New York and Pennsylvania this trouble is rather serious. The cases which the Department has had an opportunity to study have been found to be due mostly to an imperfectly known fungous disease, which appears to be induced chiefly by improper pruning and training. Allowing the vines to produce too heavy crops is also likely to increase this trouble. The subject is at present under investigation, and it is hoped to treat it separately in a later publication.

FUNGICIDES.

BORDEAUX MIXTURE.

Bordeaux mixture is the most efficient fungicide for general use at present known.

The 5-5-50 formula.—For ordinary use in combating grape diseases the following formula has given excellent results:

Copper sulphate (bluestone or blue vitriol)	pounds..	5
Fresh stone lime	do.....	5
Water	gallons..	50

At least 100 gallons of the mixture are generally prepared at one time. This amount can be made by using twice the quantity of each material directed to be used for 50 gallons, and for 150 gallons three times the quantity must of course be used.

The 4-4-50 formula.—A somewhat weaker mixture, prepared according to this formula, has been successfully used in some cases and may perhaps prove generally satisfactory if properly made and thoroughly applied:

Copper sulphate	pounds..	4
Stone lime	do.....	4
Water	gallons..	50

The 6-3-50 formula.—Bordeaux mixture for use before the buds open in the spring should be prepared according to this formula:

Copper sulphate	pounds..	6
Stone lime	do	3
Water	gallons..	50

For applications to dormant vines a simple solution of copper sulphate is often used, consisting of 4 pounds of copper sulphate to 100 gallons of water. The strong Bordeaux mixture is more efficient, however, as it adheres better to the vines and is effective for a longer period.

PREPARATION OF BORDEAUX MIXTURE.

Failure to secure satisfactory results from the use of Bordeaux mixture is frequently due to lack of proper care and thoroughness in its preparation, or to the use of poor material. All ready-made preparations of Bordeaux mixture in the form of a paste or a dust should be avoided, as the chemical constituents do not properly combine in these conditions. A definite chemical compound is desired, and this can only be produced in proper form and condition by carefully following the directions given below.

Stock Solutions.

In order to carry on the work with the greatest convenience and economy, a considerable quantity of copper sulphate and of lime should be ready for immediate use. The copper and the lime may be prepared and kept most conveniently in the following manner:

Copper sulphate solution.—Take 100 pounds of copper sulphate (bluestone), place it in a gunny sack, and suspend it in a 50-gallon barrel of water. Kerosene or whisky barrels will be found very convenient. The copper sulphate will all dissolve in from 12 to 18 hours if suspended in a loosely woven sack, but if it is thrown loose in the bottom of the barrel it will take several days and considerable stirring to dissolve it. This makes a solution containing 2 pounds of copper sulphate to each gallon of water. This may be kept as long as desired without deterioration, if covered so as to prevent evaporation.

Lime solution.—The various kinds of ground and prepared lime can not always be relied upon; stone lime is therefore to be preferred, and is more likely to give uniformly satisfactory results. Slake 100 pounds of stone lime in a 50-gallon barrel, adding the lime in small quantities with plenty of water and mixing thoroughly. When the lime is all slaked fill the remainder of the barrel with water. You will now have a stock preparation of lime which when thoroughly mixed will be thin enough to dip and pour readily. Each gallon of this preparation will contain 2 pounds of the stone lime. This may be kept under cover and used as needed. Where large quantities of material are being used it is desirable to have two or more barrels each of stock lime and bluestone instead of one, so that the bluestone in one barrel may be dissolving while that in the other is being used.

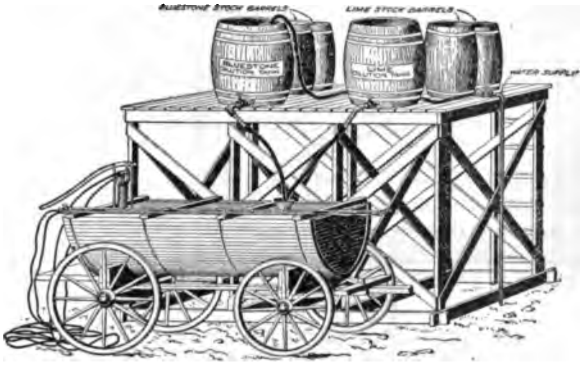


FIG. 21.—Elevated platform for making Bordeaux mixture. The water supply is merely indicated. In the absence of a water supply in pipes a water tank may be used. The materials flow by gravity directly into the spraying tank, which thus serves as the mixing tank.

Mixing Copper Sulphate Solution and Lime Solution.

To prepare a 100-gallon spray tank of Bordeaux mixture, take two 50-gallon barrels and fill them nearly full of water; to one barrel add 5 gallons of the bluestone stock solution, which will be the equivalent of 10 pounds of bluestone. To the other barrel add 5 gallons from the barrel of the stock lime preparation, which will be equal to 10 pounds of stone lime. Mix the lime thoroughly and allow the contents of the two barrels to run together into a trough, or through hose attached at the bottom of the barrels into the tank of the sprayer, as shown in the illustration (fig. 21).

If an insecticide is to be used, it may now be added to the mixture.

After the mixture is prepared it should be used very soon, and not be allowed in any case to stand more than a few hours before using.

The quantities mentioned in this account of the preparation of Bordeaux mixture will give 100 gallons of the 5-5-50 formula. For the other formulas, the manner of preparation is precisely the same, and the necessary changes in quantities of bluestone and lime are easily calculated.

Straining.

In order to avoid clogging the spray nozzles the mixture must be thoroughly strained before it goes into the sprayer. A strainer of brass wire cloth, 20 or 22 meshes to the inch, should be used for this purpose. A very convenient and satisfactory strainer is shown in the accompanying illustration (fig. 22). It consists of (1) a tight outer box about 1 foot square, with a heavy bottom, into which a piece of 1½ to 2 inch gas pipe is fitted as an outlet, and (2) an inner box, smaller and lighter, which will drop easily into the outer one. The wire cloth, securely fastened, forms the bottom of the inner box, and is sloped at an angle of about 30 to 35 degrees. The slanting of the sieve prevents clogging, and the removability of the inner box greatly facilitates cleaning. A narrow strip should be nailed about the outside of the inner box at the top, so as to prevent its dropping too far down; this will facilitate its removal.

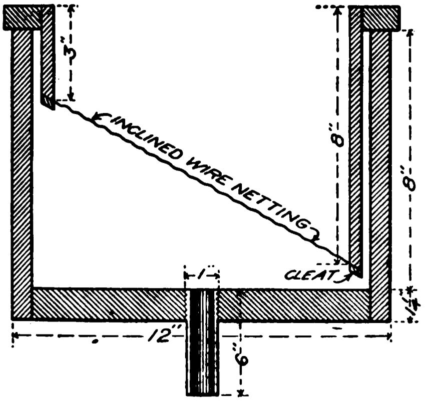


FIG. 22.—Cross section of strainer for Bordeaux mixture. The inner frame with inclined wire strainer fits loosely into the outer box.

Elevated Platform.

A platform similar to the one shown in the accompanying illustration (fig. 21) will be found very convenient in handling the stock solutions and the mixture. This should be located near a good water supply. A tank elevated above the mixing platform and filled by a windmill pump will be found very convenient, or the platform may be located beside a stream or spring and the water be raised by means of a force pump.

NONSTAINING PREPARATIONS.

Bordeaux mixture, when used late in the season, is apt to stain the fruit more or less and interfere with its sale. It is therefore best to use for the final applications some other fungicide which is not open to this objection. The amount of the mixture which may adhere to the grapes at the time they are picked is not sufficient to injure the consumer under normal or average conditions. Consumers, however, object to stained fruit, and this fact must be taken into account.

The following preparation, though not quite so efficient a fungicide as Bordeaux mixture, does not stain the fruit, and should, therefore, be used for the last two applications.

Burgundy mixture (*copper carbonate mixture*).

Copper sulphate	pounds..	2
Sodium carbonate (sal soda)	do....	3
Water	gallons..	100

Dissolve and dilute each of the two chemicals to 50 gallons and allow them to run together into the spray tank in the same manner as in making Bordeaux mixture.

Insect poisons should not be added to this mixture.

Ammoniacal copper carbonate has been recommended in previous Farmers' Bulletins as a nonstaining application. Copper acetate has also been suggested for the same purpose. According to our present knowledge Burgundy mixture is about as safe and efficient as either of these and costs less than half as much.

A simple solution of copper sulphate, using 1 pound to 100 gallons of water, is frequently used for the final applications, but is much inferior to the Burgundy mixture.

SPRAYING.

SPRAYING APPARATUS.

The selection of a spraying outfit is a very important matter and should be carefully considered by anyone who is about to undertake this work. It will be found far better in the end to invest a larger amount at the start than to purchase a cheap outfit which may not be best adapted to the work and may prove a source of vexation, delay, and expense.

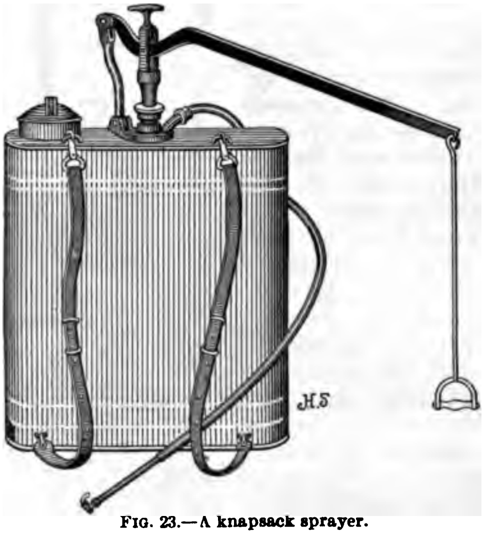


Fig. 23.—A knapsack sprayer.

Good machines are frequently ruined in a few seasons by lack of proper care. It will be found a great saving of time and expense to wash out the spray tank, pump, and nozzles thoroughly after using and keep the machine under cover. The packing of the pump should also be looked after frequently.

The three most essential factors concerned in the operation of spraying are the power, the pump, and the nozzle.

Power.

Hand-power, horse-power, carbonic-acid gas, compressed air, and engines run by steam, gasoline, and kerosene are all used for spraying. In order to produce a satisfactory mist-like spray the power must be contant and sufficient to keep up the necessary pressure.

Hand-power.—Excellent work can be done by hand-power, using a knapsack or barrel pump (figs. 23, 24), but the time and labor required make it objectionable in large vineyards. In small vineyards it may be used to advantage.[a]

---

[a] For a general discussion of spraying machinery see Farmers' Bulletin 243, Fungicides and Their Use in Preventing Diseases of Fruits, by M. B. Waite.

Horse-power.—Used in connection with a geared sprayer, horse-power is in very general use in vineyards. There are a number of forms of these sprayers on the market, most of which are unsatisfactory, as it is not always possible to keep up sufficient and uniform pressure without driving so fast that the vines can not be properly covered with the mixture. One of these machines is shown in figure 25. This, with the addition of the two nozzles directed downward from above, does fairly good work.

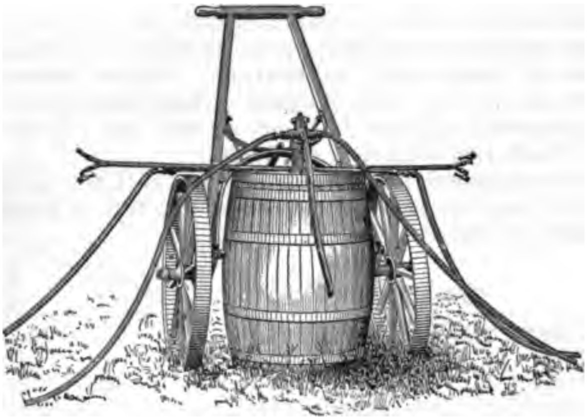


FIG. 24.—A barrel and cart spraying outfit.

Carbonic-acid gas furnishes excellent power and does entirely satisfactory work in spraying. The pressure can be easily controlled and there is no pump to get out of order. It is considered somewhat more expensive than horse-power or gasoline power, however, and unless one is so situated that the drums can be recharged promptly, serious delays may occur which will interfere with the success of the work. A gas spraying outfit is shown in figure 26. A smaller tank mounted on a two-wheeled cart is also used.

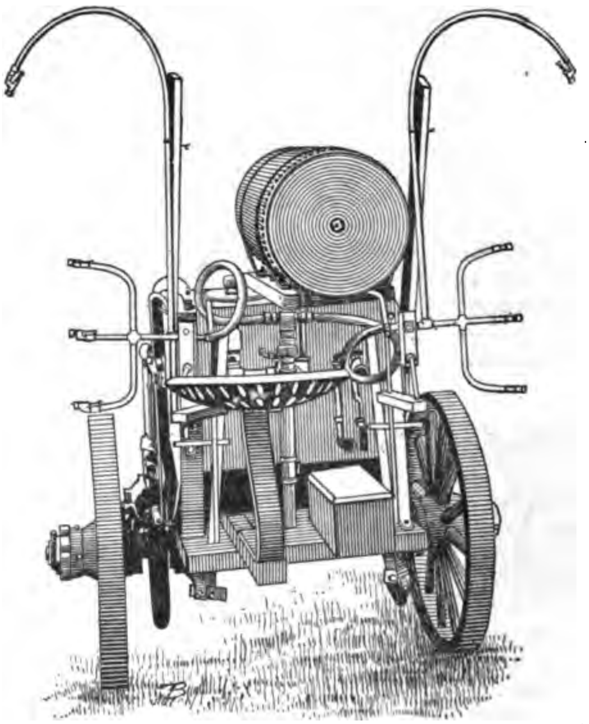


FIG. 25.—A geared horse-power vineyard sprayer. This is provided with a compressed air tank and an extra nozzle on each side directed downward in order to spray the tops of the vines.

Compressed air is used in the same way as gas (fig. 27). The air is compressed by means of a stationary engine and air pump. Excellent work may be done with such a machine. The relative expense of this as compared with other forms of power has not, so far as we know, been accurately determined. It is, however, preferred by some growers.

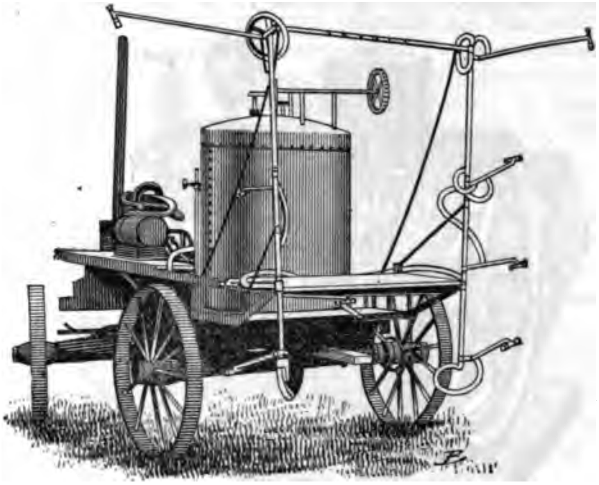


FIG. 26.—A carbonic-acid-gas sprayer.

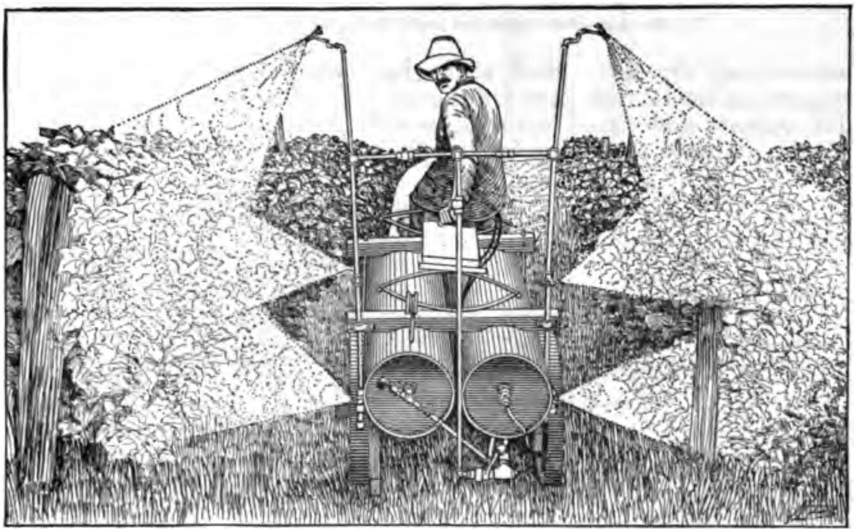


FIG. 27.—A compressed-air sprayer in operation.

Gasoline.—Steam engines are sometimes used, but they are usually found too bulky and heavy for vineyard work. Alcohol has not yet apparently been used in this connection. A cheap denatured alcohol may perhaps eventually replace gasoline. At present, however, gasoline furnishes the most convenient and economical power. A compact and strong engine of two or three horsepower, with pump made especially for spraying purposes, will be found most satisfactory (fig. 28). Such an engine mounted upon a light handy wagon similar to that shown in figure 29, with a tank holding 100 to 150 gallons and fitted with adjustable rods and nozzles (fig. 30), would perhaps make the most efficient and economical outfit for extensive vineyard use. With such an outfit one may drive slowly and cover the vines and foliage thoroughly. If one has orchard fruit to spray, an engine is still more desirable. It may also be used for other purposes about a place.

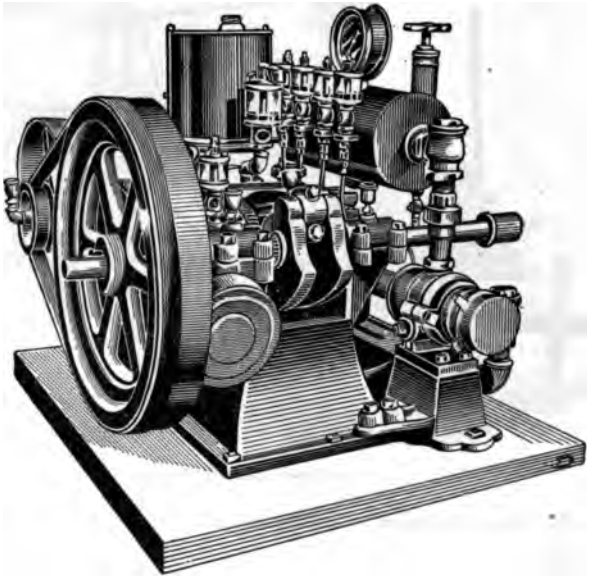


FIG. 28.—A gasoline engine and pump made especially for spraying.

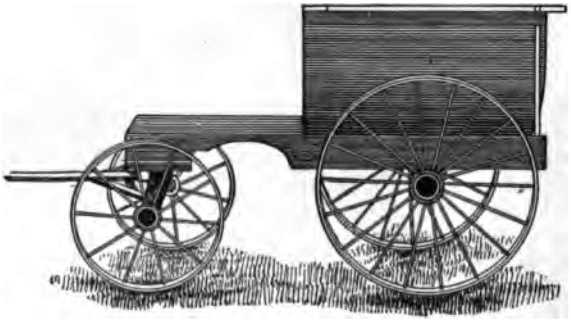


FIG. 29.—Wagon and tank adapted to vineyard spraying. A gasoline engine may be fitted in front and the upright adjustable rods and nozzles shown in figure 30 added.

Pumps.

The pump is a very important part of a spraying outfit. It should be strongly and carefully constructed and especially made for spraying purposes. For use with Bordeaux mixture all the working parts coming in contact with the mixture should be made of brass. Iron is acted upon by Bordeaux mixture and is finally destroyed. Leather valves should be avoided for the same reason. A good-sized air chamber is also an essential feature in connection with the pump, as it helps to maintain a uniform pressure.

Two of the styles of pumps in common use are shown in the accompanying illustrations (figs. 31, 32).

Nozzles.

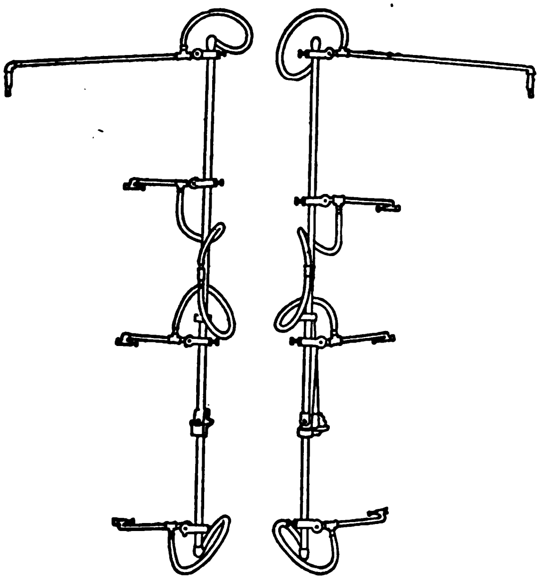


FIG. 30.—Adjustable rods and nozzles for vineyard spraying.

Being supplied with satisfactory power and pump, the next important feature of the outfit is the spray nozzle. A nozzle of the Vermorel or cyclone type (see fig. 33), when properly made, will give a fine mist-like spray and is to be preferred to other types. It is to be regretted that most of the nozzles in general use, whether of this form or some other, are not made with sufficient care. The nozzles should be made of brass and the inlet chamber and the opening through the cap should be very smoothly and accurately drilled. The frequent use of a degorger will gradually wear the opening in the disk and make it irregular. For this reason interchangeable disks are desirable. These should be made of hardened brass, steel, or some other material which is neither attacked by the chemicals in the mixture nor easily injured by a degorger. Iron, zinc, and tin are worthless and should be carefully avoided. A poor nozzle wastes power and material and sprinkles the vines instead of spraying them, while the result of the work is not satisfactory. A properly made nozzle should give a fine mist-like spray with a minimum amount of pressure.

APPLICATION OF SPRAY MIXTURES.

Having a satisfactory outfit and the mixture properly prepared, there is still liability of failure unless the mixture is applied properly and at the proper times.

In spraying, the aim should be to cover as nearly as possible the entire surface of the vines, foliage, and fruit with the mixture, in order to destroy all the germs of the various parasites which may come in contact with the plant, and to destroy the insects which may feed upon the foliage, fruit, or buds.

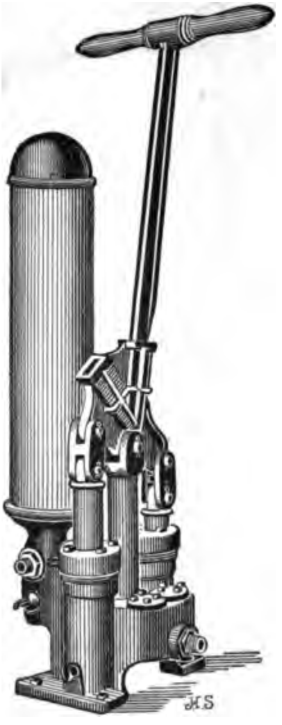


FIG. 31.—A large hand spray pump with double vertical cylinders for use with tank outfits.

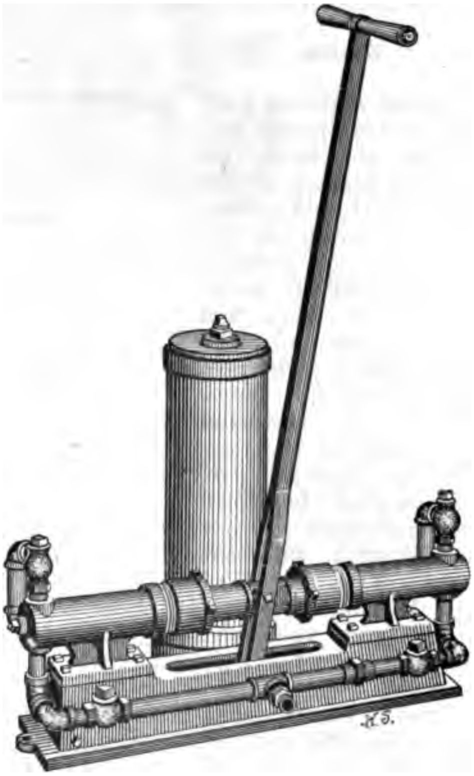


FIG. 32.—A large hand spray pump with double horizontal cylinders for use with tank outfits.

The accompanying illustrations (figs. 34 and 35) show two grape leaves to which Bordeaux mixture has been applied. Figure 34 shows a leaf properly sprayed. Figure 35 shows a leaf which has been sprinkled rather than sprayed. Too much of the mixture having been applied, it has run together in drops or fallen to the ground and been wasted. The leaf shown in figure 35 is, however, covered better than is generally the case in vineyard spraying. Thorough work is absolutely necessary if satisfactory results are to be secured. The nozzles should be carefully adjusted and directed, and should also be watched to see that they do not clog. The rods with adjustable nozzles, such as shown in figure 30, have given best results. The team should be driven slowly and at the proper distance from the vines.

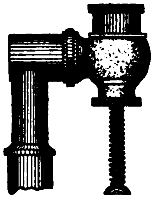


Fig. 33.—A vermorel spray nozzle.

Time of application.

First application.—In case fungous diseases are causing serious loss, or the vineyard has not been sprayed before, a thorough application of the strong Bordeaux mixture mentioned (6-3-50 formula) should be made just before the buds open. For the grape-growing regions of New York, Pennsylvania, Ohio, and Michigan this will usually be about May 1. If injury from the grapevine flea-beetle is anticipated, an arsenical should be added to the mixture.

Second application.—This should be made just before the blossoms begin to open, which will be about the 1st of June for the States mentioned. The ordinary Bordeaux mixture (5-5-50 furmula) should be used, and with an arsenical added the spray will be effective against the grapevine flea-beetle, the rose-chafer, grape curculio, and the first brood of the grape berry moth and the grape leaf-folder, respectively.

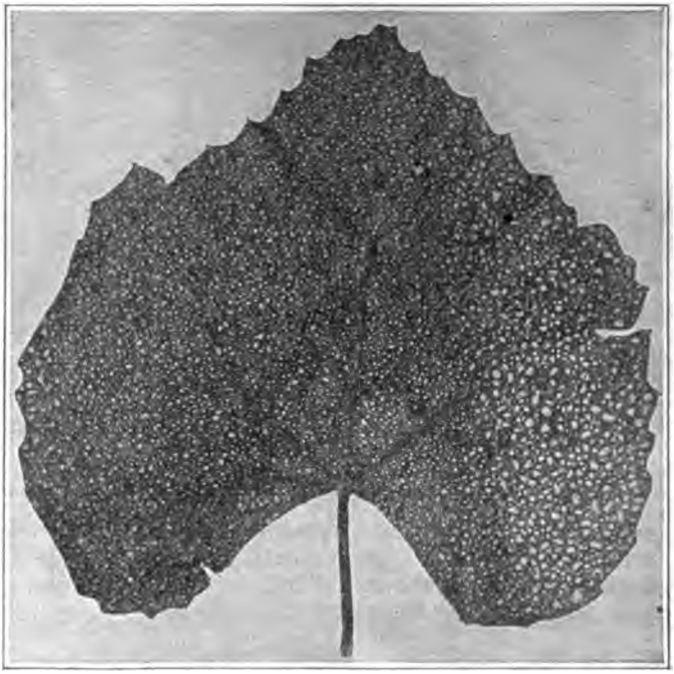


Fig. 34.—A grape leaf properly sprayed, showing the surface covered with minute drops of the Bordeaux mixture.

Third application.—This should be made as soon as the blossoms fall, using Bordeaux mixture as above and an arsenical to give further protection against the insects mentioned and to poison the grape root-worm, the beetles of which are at this time just beginning to appear.

Fourth application.—This should be made within 10 days after the third application, using Bordeaux mixture as above and an arsenical. This and the preceding applications are especially important for the grape root-worm and the grape curculio, and will also afford further protection against the grape berry moth and the leaf-folder. For the insects first mentioned, it is very important that this application be delayed not longer than 10 days after the third.

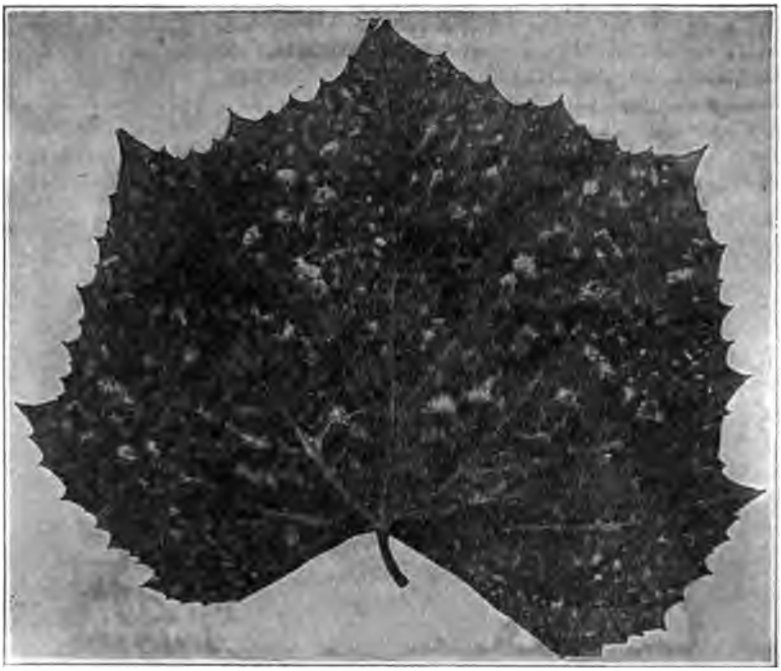


FIG. 35.—A grape leaf improperly sprayed. The mixture has been sprinkled upon the leaf instead of being sprayed in a fine mist, and the surface is not evenly and properly covered.

Fifth application.—[illegible] made two weeks after the fourth, using the Burgundy [illegible] recommended, and no arsenical.

Sixth [illegible] This [illegible] made about two weeks after the [illegible] Burgundy [illegible] mixture only.

[illegible] TREATMENT.

[illegible] mixture is usually [illegible] of average size. [illegible] much as 150 gal- [illegible] will be better to [illegible] cost for labor and [illegible] applications, [illegible]

Issued April 18, 1907.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 285.

THE ADVANTAGE OF PLANTING HEAVY COTTON SEED.

BY

HERBERT J. WEBBER and E. B. BOYKIN,
Physiologist in Charge and Special Agent, respectively,
Plant Breeding Investigations, Bureau
of Plant Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., March 5, 1907.

Sir: I have the honor to transmit herewith a paper entitled "The Advantage of Planting Heavy Cotton Seed," prepared by Dr. H. J. Webber, Physiologist in Charge of the Plant Breeding Investigations of this Bureau, and Mr. E. B. Boykin, a special agent of the same office. This paper embodies the results of experiments in the separation of cotton seed, and shows the advantage to growers of making such a separation of their seed for planting. The methods presented and the apparatus described are new and are of great importance to the cotton industry. The paper should, therefore, be distributed broadcast among cotton planters, and I recommend its publication as a Farmers' Bulletin.

Very respectfully,
B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
Heavy versus light seed 5
Preparation of seed for separation 6
Method of separating seed 9
Tests of separated seed 11
Separation of Sea Island cotton seed 14
How to obtain the necessary apparatus for cotton seed separation 16

ILLUSTRATIONS.

Page.
FIG. 1. Seeds of fuzzy Upland cotton, before and after rolling 6
2. Apparatus used in rolling seed 7
3. Seed separator as modified and used in experiments 9
4. Plan of seed separator 10
5. Section of first sieve, showing size of meshes 11
6. Separated Sea Island cotton seeds 15

B. P. I.—270.

THE ADVANTAGE OF PLANTING HEAVY COTTON SEED.

HEAVY VERSUS LIGHT SEED.

The importance of using heavy seed is in many crops well established. Seed grains, for instance, are quite generally subjected to some degree of separation. In tobacco the great importance of using large and heavy seed has been demonstrated by Mr. A. D. Shamel in the course of experiments conducted by the Bureau of Plant Industry of the Department of Agriculture. In this crop the tests of light and heavy seed have proved that the best developed and most vigorous plants are always produced from the heavy seeds, while the light seeds produce small, irregular, and undesirable plants.[a]

To insure a vigorous development of plants it is important to have a large quantity of nutriment stored in the seeds. Heavy seeds are the only ones which meet this condition, and, as a rule, the heavier they are in proportion to their volume the higher is the percentage of germination, the more rapid is the growth of the resulting plants, the more resistant are they to disease and adverse conditions, and the greater is their productiveness. Light seeds, on the other hand, germinate poorly and produce plants of low constitutional vigor, which are readily attacked by diseases and which possess a comparatively low degree of productiveness.

It is therefore important to subject seed for planting to some process of separation by which the light and inferior seeds are eliminated. Such a separation can readily be effected with seeds having smooth seed coats, as, for instance, corn, wheat, peas, and tobacco. A number of methods have been devised which are applicable to the separation of such seeds, and in the case of a number of important crops extensive experiments have been conducted with separated seeds. The results strongly indicate the superiority of heavy seeds and the advisability of separation.

Comparatively little experimental work has been done in the separation of cotton seed, but in view of the beneficial results obtained in the case of other crops there is no apparent reason why similar results should not be obtained with cotton by a separation which eliminates the light and inferior seeds. The seeds of Upland varieties of cotton are covered with a dense fuzz (fig. 1, A), which holds them together and prevents their separation by any of the methods which are applicable to the separation of smooth seeds, and heretofore no practical method has been devised to meet these conditions. In view of this fact and the possibility of increasing the yield in this way, it was decided to make some effort to devise a method which would be adapted to the separation of cotton seeds. Fortunately, the experiments have been very successful, and it is now possible to recommend what appears to be a thoroughly practicable and successful method.

---

[a] Shamel, A. D. The Improvement of Tobacco by Breeding and Selection. Yearbook, Department of Agriculture, 1904, pp. 440–452.

PREPARATION OF SEED FOR SEPARATION.

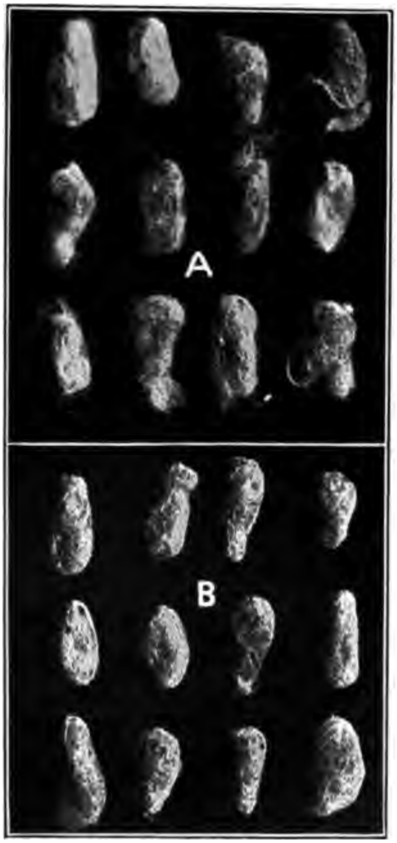


FIG. 1.—Seeds of fuzzy Upland cotton, before and after rolling: A, untreated; B, rolled by flour-paste method.

It was evident from the beginning that the fuzz which covers the seed in ordinary varieties of cotton would either have to be removed or treated in some way to paste it down and thus prevent the seeds from clinging together. To remove this fuzz would probably require the use of expensive machinery which the majority of growers could not purchase or to which they would not have access. However, it was found that by rolling the seeds in some finely pulverized material and water, the fuzz could be so thoroughly pasted down as to prevent the seeds from adhering together and thereby enable each one to be acted upon individually in the process of separation. This rolling process is no doubt familiar to many growers, as it has been frequently employed in preparing seed for planting in cases where planters are to be used which are not adapted to fuzzy seed. The old planters which first came into use required the rolling of the seed before planting, and some of the modern planters also require this treatment.

The necessary apparatus for rolling the seeds can be provided at a very small cost. The one used in connection with these experiments consists of a wooden hexagonal box with a wooden axle extending through its center, supported at each end, and having a crank attached at one end for turning (fig. 2). It has an opening on one side through which the seeds can be put in or taken out and which is closed during the rolling process by means of a hinged door. Probably a more convenient way of making such an apparatus is to use a large barrel, similar to a petroleum barrel, through which a wooden axle can be inserted, and the other details arranged according to the above description.

There are a number of materials which can be used to roll the seed in, and almost any finely pulverized material will do; but among those which are most likely to be available on a farm are ashes, acid phosphate, and fine, dry soil. A small quantity of such material and water should be sprinkled through the seed as it is put into the barrel, and more should be added gradually as the rolling proceeds until there is sufficient to thoroughly paste down the fuzz. The quantity will vary somewhat according to the variety of seed, for it will take more for a given quantity of small seeds than of large ones, as they will have a greater surface area. However, with a little experience it is very easy to determine how much should be used to get the best results. It is important to guard against the use of excessive quantities, especially of water, as this will prevent a satisfactory separation. The rolling should be very thoroughly done and should continue until the seeds fall apart very readily. This rolling process is not entirely satisfactory, as it probably introduces a slight element of error in the separation, owing to the fact that in some cases it slightly changes the relative weights of the seeds.

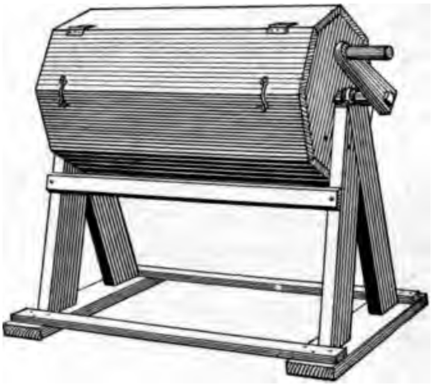


FIG. 2.—Apparatus used in rolling seed.

In the first separation experiments conducted by the writers the above methods of rolling and cementing down the fuzz were followed. It was later found that the same object could be accomplished much more easily and thoroughly by using flour paste, a material which, so far as the writers are informed, has never before been used. To treat seed by this method, take an ordinary drinking glass full of flour (from 4½ to 5 ounces) and mix it thoroughly with one pint of water, stirring it until the flour is thoroughly mixed with the water and not lumpy. Then add 1 quart more of water and boil until it thickens and becomes pasty. It will be observed that this is the same process used by housewives in making flour paste and flour gravy.

After cooling the paste, place 1 bushel of cotton seed in the rolling apparatus and pour the paste over it. Then close, and roll the seed from seven to ten minutes, after which it can be dumped out and spread on the floor of the barn or in some other convenient place to dry. It has been found that seed treated in this way can be spread out in a layer from 3 to 4 inches deep and dried without difficulty. It was at first thought that the seeds would stick together in drying, but this has not proved to be the case. If more than one bushel of seed is to be rolled at one time, increase the quantity of paste used in proportion. By this method the seeds are coated with a thin pellicle of paste, which sticks the fuzz down firmly and allows the seeds to fall apart readily (fig. 1, B). The seeds after treatment remain in the same condition permanently until moistened or soaked in water, and the paste in no way interferes with their use in feeding or for other purposes, if desired later.

When the fuzz is stuck down by using ashes, fine soil, etc., as described previously, the seeds must be separated while still quite damp, as the hairs on drying straighten out and the dust rattles out, so that they begin to adhere again. This necessity of separating them while still moist increases the element of error in the separation, owing to the weight of both the water and the material adhering to the seed. Again, if the rolling is to have any effect in the planting, the seeds must be put in the planters and planted while still moist. This bunches the work of separation and planting so much as to make it difficult for the planter to carry it out successfully. By using the flour-paste method these difficulties are avoided. The rolling and separation of the seed can be done in the winter, when there are no rushing farm operations under way and when there is an abundance of labor. Separating the seed at this time will cost the planter scarcely anything, as it can be done at odd times when the helpers would otherwise be idle. The seeds treated by the paste method are dried before separation, so that the element of error is reduced, and the seeds after treatment remain in the same condition as long as they are kept dry. In the spring they will thus be in excellent condition to run through the planter easily. By this method, furthermore, the fuzz is so completely pasted down and the seeds roll apart so easily that it is believed they can be planted with perfect satisfaction in the ordinary double-row corn planters, which check the seed in hills. As there is a growing tendency to plant cotton in rows both ways, so that it may be cultivated more completely by machinery, it is believed that this simple discovery of attaching the fuzz by use of flour paste is of great importance to the industry as a whole. If planted with a corn planter and dropped at regular distances without reference to placing them in rows both ways, this method will even then be of great importance, as it facilitates dropping, insures uniformity in the number of seeds dropped, and does away with much of the labor necessary in thinning when cotton is planted in the ordinary way.

METHOD OF SEPARATING SEED.

In searching for a practical method of separating the heavy from the light seeds after they had been rolled as previously described, several available fanning mills and shaking machines of various types were tested, but in no case was a satisfactory separation obtained with existing machines. The experiments with air-blast fanning mills, where the current of air is directed for a short distance through a flue, gave indications of success. By experiments with such machines it was found that a successful separator must contain a flue of considerable length through which a strong blast of air can be directed and in which the seed may be exposed fully to the action of the air. In a long tube the seeds boil up and down under the action of the air current, giving an opportunity for the heavy ones to fall, while the light ones are carried on and finally blown out. A plan was devised for a special machine, but it was found that one of the ordinary types of air-blast fanning mills could be modified into about the type of machine desired and embrace the principles involved in this plan.

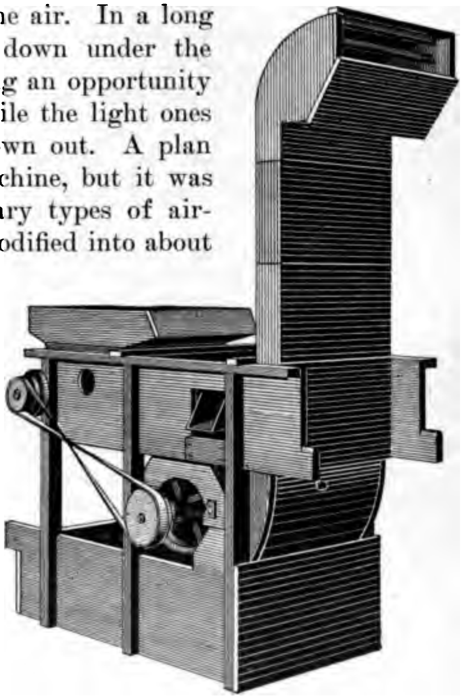


FIG. 3.—Seed separator as modified and used in experiments.

The machine which was modified[a] (fig. 3) was arranged for the seeds to be fed from a hopper (fig. 4, *a*) on to a vibrating screen (fig. 4, *b*, and fig. 5) which would catch the wads of seed and any large bodies of foreign matter and discharge them (fig. 4, *d*) before they reached the flue, but which would allow the individual seeds to pass through its meshes to another vibrating screen with fine meshes (fig. 4, *c*), which delivered them into a short flue (fig. 4, *e*), where they were brought in contact with a current of air driven by a fan from below, which carried the light seeds out through the top of the flue and allowed the heavy ones to drop through into a box below.

---

[a] A patent on the apparatus described has been applied for on behalf of the Department of Agriculture in order that the public may make and use the device without the payment of royalties.

The principal modifications were to change the gearing so that the fan could be run fast while the frame holding the screen vibrated slowly, and to put additional sections in the flue for the purpose of increasing its length so as to give a longer space in which the separation can take place (fig. 4, *g*, *g*, *g*). The separator flue in the original machine from the point of entrance of seed (fig. 4, *e*) to point of discharge of light seed above was only 6 inches in length. This flue, or tube, was extended to a length of 4½ feet by adding four sections of box-like form which could be set one upon the other and fitted together firmly. This sectional construction of the flues allowed of experimentation with flues of different lengths. The method of construction is illustrated in figure 4, *k*.

The separation depends upon the fact that the effect of the blast exercises itself in a different manner upon the seeds according to their size and specific weight; those seeds having the greatest weight relative to their size drop through the blast, while the light ones having a large surface in proportion to their weight are unable to resist the blast and are therefore carried off through the flue. The separation, therefore, is not entirely in accordance with the absolute weight or size of the seeds, but this does not seem to be necessary, as it is more important to get those having the greatest weight in proportion to their volume. It quite frequently happens that large seeds are relatively very light and inferior owing to shrunken or imperfectly developed kernels, yet they may have a rather high absolute weight. They are, however, probably not so desirable as smaller seeds having the

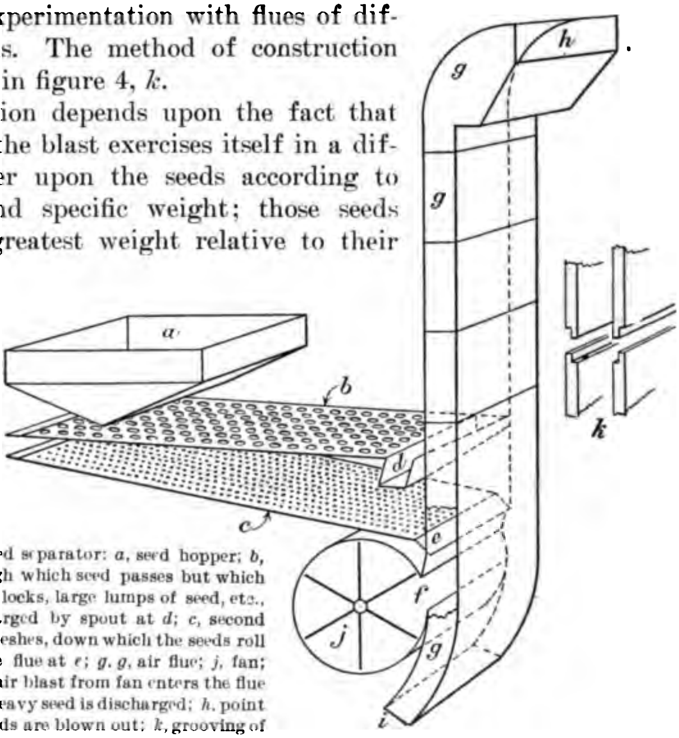


FIG. 4.—Plan of seed separator: *a*, seed hopper; *b*, first sieve, through which seed passes but which removes diseased locks, large lumps of seed, etc., which are discharged by spout at *d*; *c*, second sieve, with fine meshes, down which the seeds roll and fall into the flue at *e*; *g*, *g*, air flue; *j*, fan; *f*, point at which air blast from fan enters the flue *i*, point at which heavy seed is discharged; *h*, point at which light seeds are blown out; *k*, grooving of top and bottom of sections of flue, showing how sections are constructed to fit into each other.

same absolute weight, because their hulls being larger represent a greater percentage of their weight; consequently the kernel, which is the most important part of the seed, necessarily represents a smaller percentage of the gross weight than in the case of small seeds having the same weight.

In order to secure the most satisfactory separation it is necessary to have the machine run at a uniform speed which has been tested and found to give good results. The best separation will thus be obtained where the machine can be attached to some power plant or run by a gasoline or kerosene engine. In many cases power can probably be obtained in the gins. While it is better to procure power from an engine, a very fair separation can be obtained with hand power. To secure a thoroughly satisfactory separation requires some practice and experience with the machine, as the air blast must be properly regulated. If only one separation is to be made the speed must be regulated so that from one-fourth to one-half of the seed is blown out at the top of the flue as light seed. While in general it is only the light seed that is blown out, still some good seed will doubtless in all cases be blown over. As the light seed can be utilized in other ways, this is not a serious fault. If the most perfect results are desired, the heavy seed of the first separation should be run through the separator a second time. A double separation, however, in most cases will probably not be found practicable or necessary if the first separation has been properly done.

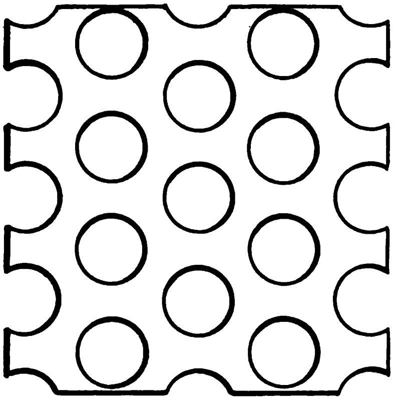


FIG. 5.—Section of first sieve, showing size of meshes.

TESTS OF SEPARATED SEED.

After separation it is very easy to detect a difference in the appearance of the light and heavy grades. In the heavy grade the seeds are plumper, more uniform, and have a much better general appearance. In order to determine the relative weights of the different grades a quantity of seed was separated into four grades, which for convenience were designated as heavy, medium, light, and very light, and 500 seeds were taken from each grade and accurately weighed, giving the following results: The heavy seeds weighed 81½ grams; the medium, 77½ grams; the light, 74½ grams, and the very light, 62½ grams. After separating another lot of seed into three grades—heavy, medium, and light—a box of seed containing almost a bushel was taken from each grade and weighed, with the following results: The heavy seed weighed 25¼ pounds; the medium, 22⅝ pounds, and the light, 20⅝ pounds. It is thus demonstrated that the separation is in accordance with the weight of the seeds.

To determine the relative percentage of germination of seeds from the different grades and as far as possible to get suggestions as to the relative vigor of the resulting plants, a small test was made in the greenhouse. For this test a quantity of seed was separated into four grades—heavy, medium, light, and very light—and 350 seeds were taken from each grade and planted in practically pure sand. The results are given in the following table:

TABLE 1.—*Germination of 350 seeds of various grades planted in greenhouse on March 2, 1906.*

Grade of seeds.	Number of seeds germinated.							
	Mar. 8.	Mar. 9.	Mar. 10.	Mar. 11.	Mar. 12.	Mar. 13.	Mar. 14.	Mar. 16.
Very light	80	115	174	188	218	224	226	228
Light	52	86	196	253	290	290	292	294
Medium	26	55	169	236	261	270	272	273
Heavy	20	54	175	246	279	292	297	305

For some cause the plants from the medium grade began damping off very soon. It is likely that they were watered too freely. In any case the results from this grade are not considered reliable. It will be observed that a large percentage of all grades germinated, but that the highest percentage of germination was in the case of the heavy seeds. An interesting point in this connection is the fact that the light seeds germinated more quickly than the heavy ones, as can be seen by referring to the table. However, the most striking difference was in the appearance of the resulting plants from the various grades. Many of those from the light grades were yellow and unhealthy in appearance, while those from the heavy grade appeared to be much stronger and more vigorous.

In order to determine what advantage would be gained by eliminating in such separation the light and inferior seeds and planting only the heaviest and best developed ones, careful tests were made in 1906 at Lamar, S. C., in cooperation with Mr. C. L. Reynolds, and at Hartsville, S. C., on the farm of J. L. Croker & Co. For the test at Lamar, a quantity of Hawkins seed was separated, and the heavy seeds and the unseparated seeds of this variety were planted in alternate rows on about 2 acres of land, i. e., approximately 1 acre of each. There were twenty rows of each kind. The resulting yields are given in the following table:

TABLE 2.—*Yield of seed cotton obtained in test at Lamar, S. C.*

Kind of seed planted.	First pick.	Second pick.	Third pick.	Total yield.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Heavy (20 rows)	375	253¼	419	1,047¼
Unseparated (20 rows)	335	228	381¼	944¼

In this test the yield resulting from the heavy seed was 103 pounds, or 10.9 per cent, more than the yield from the unseparated seed.

For the test at Hartsville a quantity of Jones's Improved seed, which was grown on the Coker farm at Hartsville in 1905 and selected for planting in 1906, was separated, and about an acre of land was planted with the heavy seed and the same area with unseparated seed, the two kinds being planted in alternate rows over the entire area. There were fourteen rows of each kind, and the yields are shown in Table 3.

TABLE 3.—*Yield of seed cotton obtained in test at Hartsville, S. C.*

Kind of seed planted.	First pick.	Second pick.	Third pick.	Total yield.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Heavy (14 rows)	158¾	793	212⅞	1,164⅝
Unseparated (14 rows)	139	715¾	221⅛	1,075⅞

As shown by Table 3, in the test at Hartsville the heavy seed yielded 88¾ pounds of seed cotton, or 8.25 per cent, more than the unseparated seed.

Thus it is seen that in both of these tests, which were accurately conducted under actual field conditions, there was a substantial difference in favor of the heavy seed. If the seed cotton is rated at 4 cents a pound, the differences in the yields obtained at Lamar and Hartsville are approximately equivalent to $4.12 and $3.55 per acre, respectively. At first thought this no doubt appears to be a rather small difference, yet it must be remembered that only a very slight outlay is involved in getting this additional yield. It is estimated that the cost of separation need not exceed 10 cents a bushel. In fact, on most farms the regular laborers have sufficient spare time to do this work without any additional expense, so that practically the only expense involved is the cost of picking the extra quantity of cotton which is produced. In the case of both of our tests the separation resulted in a net profit of more than $3 an acre after deducting the necessary amount for all extra expenses. The increase in the yield on the two tests averaged only about 10 per cent, but in view of the fact that this increase does not involve a corresponding increase in expenses the profits on the crop are increased by a much greater percentage. For instance, if the profit on an acre of land is $10 under ordinary conditions, the net increase by separation is more than 30 per cent of the profit obtained without the separation.

So far as can be judged from the evidence which has thus far been obtained, this method of separation seems to afford a simple, practical, and inexpensive means of materially increasing the yield and greatly increasing the percentage of profit from a cotton crop, and it is quite likely that while it is possible to realize a greater yield it will also bring about a general improvement, or amelioration, of the variety which is grown. Should it be possible to bring about an amelioration in this practical way, it will not, of course, be comparable to scientific selection, which deals with individuals, yet it will probably lead to the progressive improvement of the crop and counteract degeneration.

In the examination of cotton in the field it is almost impossible to recognize differences in yield unless such differences are very extreme. In neither of the tests conducted by the writers at Lamar and Hartsville, S. C., could the superiority in yield of the rows planted with heavy seed be surely distinguished by the eye. It was necessary to pick and weigh the product to determine definitely the results. Planters are therefore cautioned against concluding from an examination in the field alone that separation has been ineffective. The product must actually be weighed to determine the difference in yield.

SEPARATION OF SEA ISLAND COTTON SEED.

The writers have made no tests of heavy and light Sea Island cotton seed, but there would seem to be no reason why the separation in this case should not give increased yields similar to those obtained with Upland cottons. When Sea Island and Egyptian seed are separated on the machine a very perfect separation of light and heavy seed apparently results. In connection with his experiments in 1906, Mr. W. A. Orton, of the Department of Agriculture, planted some Sea Island seed which had been separated with the apparatus previously described and made some notes on the germination of light, heavy, and unseparated seeds which show that in rows of equal length the germination was as follows: Light seed, 188 plants; heavy seed, 327 plants, and unseparated seed, 237 plants. While this experiment was not sufficiently extensive or carried far enough to show conclusively the superiority of the heavy seed, it clearly indicates what may be expected.

The A. P. Brantley Company, of Blackshear, Ga., acting under the advice of Mr. Orton, constructed a machine on the plan of that devised by the writers, and have separated large quantities of Sea Island seed for planting during 1907. The different grades of seed separated by them are shown in figure 6. The pile of seed A is the unseparated seed as it comes from the gin. Mixed with the seed is a considerable quantity of seed cotton, mainly in diseased locks, which the gins are set to throw out. These diseased or injured locks (fig. 6, B) are separated by the first sieve (see fig. 4, *b*) and are discharged without passing through the flue. This material is afterwards run through a saw gin and converted into linters, the value of which is about 5 cents a pound. The heavy seed, which is used for

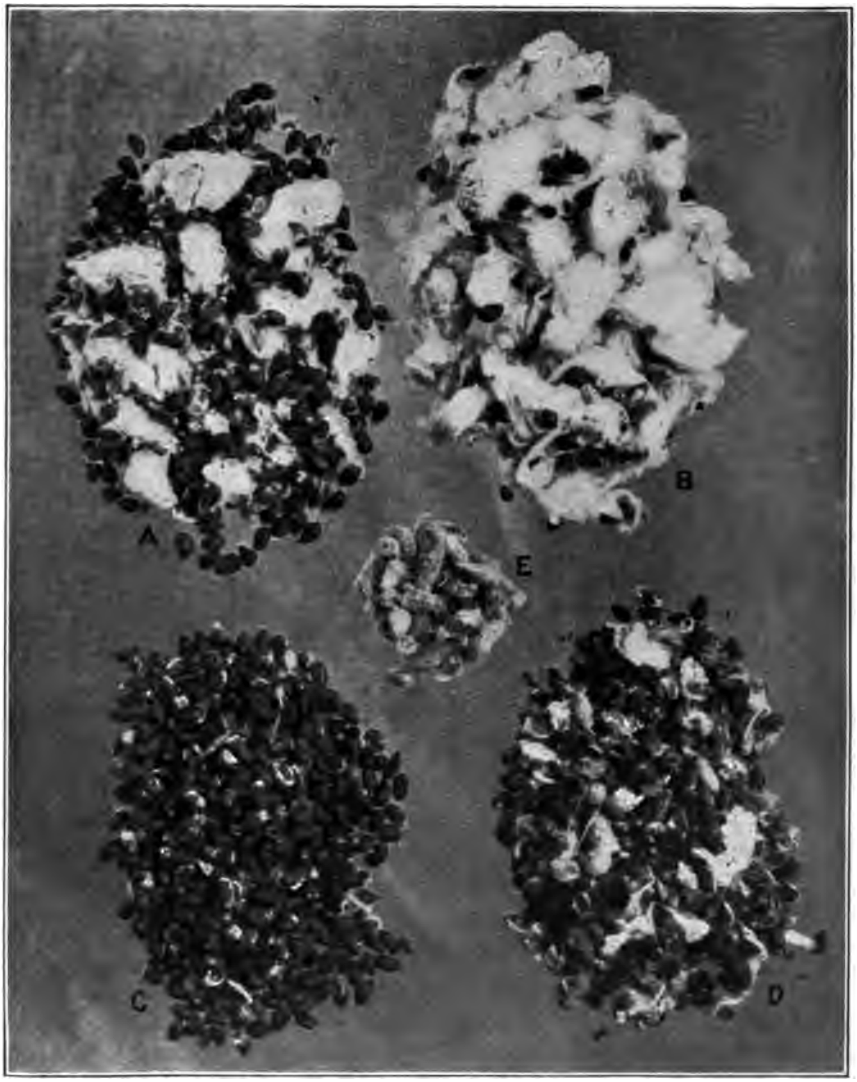


FIG. 6.—Separated Sea Island cotton seeds: A, seeds before separation; B, diseased locks and lumps removed by first (large-meshed) sieve; C, heavy smooth seed, falling down in air flue; D, light, diseased, and hybrid seed, blown out at top of flue; E, a few of the hybrid fuzzy seeds selected from mass of light seed (D).

planting, is shown in figure 6 as C, and the light seed, with which are mixed many fuzzy seeds, as D. A lot of 85 pounds of seeds after separation by the Brantley Company consisted of 76 pounds of cleaned seed, 7½ pounds of imperfect seed, and 1½ pounds of cotton. It is probable that the cleaned seed in this case should have been run through the separator again under an increased air blast, as the large percentage of cleaned seed, 76 pounds out of 85 pounds, indicates that the separation into light and heavy grades was not sufficiently thorough to obtain the full benefit of the operation.

Sea Island cotton seeds are smooth, lacking the fuzz which covers the seed of Upland cotton, and they therefore do not require to be rolled before separation. An additional advantage of importance gained by the separation of Sea Island seed is that this process will eliminate all fuzzy seeds, as these are easily caught by the air and blown out with the light seed. Great difficulty has been experienced by Sea Island cotton planters, especially in inland regions, in keeping their seed pure, owing to accidental mixture with Upland seed, which is more generally grown, and also owing to impurities introduced by accidental crossing or hybridizing with Upland varieties, which is a very general and common source of degeneration in Sea Island seed. Fortunately, such accidental hybrids with fuzzy-seeded Upland varieties practically always produce fuzzy seeds, and these hybrid seeds and seeds of any Upland cotton accidentally mixed with the Sea Island cotton are eliminated by the separation (fig. 6, D and E). In Sea Island cotton, where the success of the industry depends upon keeping up the high quality and extreme length of the fiber, it can readily be seen that the separation of the seed is of great value because of this one feature, if no other advantage is gained.

HOW TO OBTAIN THE NECESSARY APPARATUS FOR COTTON SEED SEPARATION.

The only two pieces of apparatus necessary to separate cotton seed, as described in this bulletin, are the seed roller and the seed separator. The seed roller can easily be made by any farmer from a petroleum barrel, as previously described. A seed separator of the kind described is not as yet manufactured and at the present time can not be purchased. It is, however, very easy to make an apparatus of this kind. Air-blast fanning mills, similar to that shown in figure 3, can be purchased, and a carpenter can easily make an extension of the flue, as described. Aside from the extension of the flue, the only change necessary is to modify the gearing so that the fan may be run at a rapid rate without increasing the speed of the sieve shaker. By studying the description of the separator previously given, any carpenter should be able to make these changes at slight expense to the planter.

O

Issued May 11, 1907.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 286.

COMPARATIVE VALUE
OF
WHOLE COTTON SEED AND COTTON-SEED MEAL IN FERTILIZING COTTON.

BY
E. B. BOYKIN,
Special Agent, Plant Breeding Investigations,
Bureau of Plant Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE
1907.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., March 5, 1907.

SIR: I have the honor to transmit herewith a paper by Mr. E. B. Boykin, a special agent of the Plant Breeding Investigations of this Bureau, entitled "Comparative Value of Whole Cotton Seed and Cotton-Seed Meal in Fertilizing Cotton."

Notwithstanding the fact that the oil in the cotton seed is its most valuable constituent and that the removal of the oil in no way injures or reduces the fertilizer value of the seed, very many cotton growers still continue to use large quantities of whole cotton seed as a fertilizer. This is a very wasteful practice, as an equivalent value of cotton-seed meal from which the oil has been expressed would have much greater fertilizer value. The opinion, however, prevails among many planters that the whole cotton seed possesses some advantage. Mr. Boykin has conducted experiments to demonstrate the fallacy of this belief, and the results of his experiments, which show the loss from the practice, are reported in this paper. To accomplish its object this paper should be very generally distributed among cotton planters, and I would therefore recommend that it be published in the Farmers' Bulletin series.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

COMPARATIVE VALUE OF WHOLE COTTON SEED AND COTTON-SEED MEAL IN FERTILIZING COTTON.

INTRODUCTION.

Cotton in its early history was grown entirely for its fiber, and the value of the seed was unknown. It was considered a difficult problem to find a suitable means of disposing of the seed. The most common way of doing so was to haul it to some remote place or to dump it into some convenient stream, the object being simply to get rid of it with as little trouble as possible. Less than a century ago the seed was considered a nuisance, to be destroyed, while to-day it represents a large proportion of the value of the cotton crop. The seed of a 12,000,000-bale crop is worth nearly $100,000,000 in the raw state. This change in valuation has come about by degrees. The fertilizing value of the seed was first recognized, and until comparatively recent years its only uses have been for planting and fertilizing purposes. However, its uses have been multiplied and its value greatly increased by the very recent development of the cotton-seed oil mills, which is the result of the great value now attached to the oil in the seed. Fortunately, while this oil is adapted to such a great variety of uses and has become such a valuable product, so far as is known at present it possesses none of the ingredients which give to the seed its fertilizing properties. It is composed of carbon, hydrogen, and oxygen, three elements which are essential to plant growth, but which are supplied so abundantly by nature that it is unnecessary to apply them artificially; hence, it is supposed that the fertilizing value of the seed is not diminished by extracting the oil, but that utility is given to a portion of the seed which had none before. Nevertheless, large quantities of seed are still used as a fertilizer without extracting the oil. The value of the oil in an ordinary crop of seed in this country will approximate $60,000,000.

SEED USED FOR FERTILIZER.

Granting that our theory is correct, that the oil has no manurial value, and that it can be extracted from the seed without decreasing its manurial value, it seems that true economy would suggest that it be extracted and this great sum added to the wealth of the country. Statistics show that of the crop of 1905, 61.9 per cent of the quantity produced was crushed and about 7 per cent was required for planting, leaving 31.1 per cent unaccounted for, which probably was utilized by the growers for fertilizer in the form of seed. The crop of 1905 produced nearly 6,000,000 tons of seed, and approximately 1,800,000 tons were applied to the land as a fertilizer. This contained about 72,000,000 gallons of oil, worth about $18,000,000. Thus it is seen that a large portion of this valuable product is being wasted.

ATTITUDE OF THE OIL MILLS WITH REFERENCE TO CRUSHING THE SEED.

Methods of extracting the oil have been carefully worked out. The oil-mill industry has had a phenomenal growth within recent years. Hundreds of mills have been constructed throughout the cotton belt. They have yielded handsome profits, and the mills would gladly extract the oil from the total supply of seed if they could get it from the growers. Their profits have been so great that they can certainly afford to make terms which the growers can accept. They offer from $9 to $20 a ton for the seed, or from 900 to 1,500 pounds of meal in exchange for a ton of seed. The terms vary according to the time of the season, usually being lowest at the beginning and gradually increasing until the close of the season.

POSITION OF GROWERS AS TO DISPOSAL OF SEED.

Growers differ widely in their opinions as to the best disposition to make of the seed. As shown by the statistics previously quoted, many of them accept the terms offered by the mills. No doubt some of them underestimate the value of their seed and let the mills have it too cheap, while others overvalue it and refuse to let the mills have it at all, when they could do so on profitable terms. The trouble in both cases is that the growers need more accurate information as to the relative fertilizing value of seed. In regions where artificial fertilizers are necessary meal is usually substituted for seed when the seed is disposed of, being obtained in many cases in exchange for seed. The growers can not therefore deal with the mills intelligently without knowing the relative fertilizing value of seed and meal. They need some data to guide them in deciding what terms they can accept from the mills. They need to know how much meal is approximately equivalent in effect on their crops to a given quantity of seed. In order that this information may be obtained and made available for their use the Department of Agriculture is conducting a series of experiments in comparing seed with meal. These experiments are being carried on in connection with Mr. John C. Fletcher's cotton farm at McColl, S. C., and, beginning in 1905, have thus far extended over a period of two years.

POINTS CONSIDERED IN TESTING SEED IN COMPARISON WITH MEAL.

In this work no attempt has been made to solve any technical problems. The object has been to make the test perfectly practical. Seed has been tested in comparison with meal under as nearly as possible the same conditions that exist in the practice of growers. Three tests have been made. Forty bushels of seed to the acre have been tested in comparison with 600 pounds of meal, and 30 and 20 bushels have been compared with corresponding quantities of meal. The quantities of seed tested are probably those most commonly used by growers in general practice. Acre plats were used, as it was thought that results from them would be more reliable than from smaller plats.

CHARACTER OF LAND USED FOR TESTS.

The land selected for the experiments was a dark sandy loam with a clay subsoil and quite representative of a large percentage of the cotton soils requiring artificial fertilizers. It is quite likely, however, that if these tests had been made in the same way on loose sandy or other soils from which the fertilizers can be readily leached out the results would have been different, as much of the meal would probably have been leached out without benefiting the crop, while the seed would have retained its fertilizing constituents much better. However, losses of this kind on such soils can be obviated to a very great extent by applying the readily soluble fertilizers in small quantities at intervals through the growing period. It is regretted that the experiment could not be duplicated on different types of soil.

RELATIVE QUANTITIES OF SEED AND MEAL TESTED.

It was decided that the necessary quantities of acid phosphate and kainit or potash to make a properly balanced fertilizer should be added to the seed in each case. There was some difficulty in determining how much meal should be tested in comparison with the various quantities of seed. However, this was done by estimating what quantity was necessary to make a properly balanced fertilizer with the same amount of acid phosphate and kainit or potash that was employed on the corresponding plats on which whole cotton seed was used as a fertilizer.

LASTING EFFECT OF SEED.

There is a popular belief among growers who advocate the use of seed as a fertilizer that it has a more lasting effect and is more valuable for the permanent improvement of the soil than meal. In order to determine whether or not this theory is correct, the tests were repeated the second year, all the plats being fertilized as they were the first year, so that the seed plats would have the advantage of any residual effect from the first year's manuring. As will be seen, the results so far do not prove that this theory is correct. However, to make the test more thorough, it is proposed to plant these plats in 1907 with no meal or seed, applying the usual quantity of acid phosphate and kainit or potash to half of each plat and leaving the remaining half without any fertilizer.

RELATIVE AVAILABILITY OF PLANT FOOD IN SEED AND MEAL.

There is a difference in the mehanical condition and the chemical composition of seed and meal, and owing to these differences a season which is entirely suited to one is not likely to be very favorable to the other. The seeds are incased in hulls which must decay before the crop can utilize the plant food in them, and the kernels contain oil which is supposed to retard their decomposition, so that considerable moisture is required to decompose the seed and make available the plant food. In case of a very dry season it does not become available fast enough to supply the crop, and no doubt a portion of it fails to become available until after the crop has matured. On the other hand, the fertilizing material in meal, being in a finely pulverized condition, is more likely to become available during a dry season than that in seed; but when there is excessive rainfall it is liable to become available so fast that the crop can not utilize it and a portion of it will likely be leached out and wasted. It seems, therefore, that seed has an advantage over meal during wet seasons. There was an excessive rainfall during the seasons of 1905 and 1906, but especially in 1906, in the vicinity where these tests were made. This must have favored the seed plats and militated against the meal plats; yet in spite of this condition, as will be seen from Table 1, the results of the tests very strongly indicated the advisability of using meal instead of seed as a fertilizer.

TABLE 1.—*Results of tests with 40 bushels of whole cotton seed in comparison with 600 pounds of cotton-seed meal.*

Field used for test.	Fertilizers used.				Yield in seed cotton.		
	Cotton-seed meal.	Cotton seed.	Acid phosphate.	Muriate of potash.	1905.	1906.	Average for the two seasons.
	Pounds.	*Bushels.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Plat 1	600	....	768	50	2,059	1,396	1,727½
Plat 2	....	40	768	50	1,897	1,318	1,607½
Difference in yield in favor of meal	....	....	....	....	162	78	120

In 1904 the land used for these tests was planted to corn and produced about 40 bushels to the acre. A heavy crop of pea vines was also grown on the land and the vines were turned under in the winter with a 2-horse turn plow. Later the land was laid off and bedded out eight furrows to the row with a 1-horse turn plow. The seed was applied to plat 2 and covered early in the year to prevent germination. All other fertilizers for both plats, including the meal for plat 1, were applied at the time of planting. The crop was cultivated in the usual way. Applications of 768 pounds of acid phosphate and 50 pounds of muriate of potash were made to both the seed and the meal plats.

In 1905 the meal plat produced 2,059 pounds of seed cotton, 162 pounds more than the seed plat, and in 1906 it produced 1,396 pounds, 78 pounds more than the seed plat, making an average of 120 pounds more for the two seasons. To reduce this difference to a money basis it is necessary to consider the relative market value of the seed and meal. At $16 a ton, 40 bushels of cotton seed are worth $9.60, and at $25 a ton, 600 pounds of meal are worth $7.50, or $2.10 less than the seed. This amount added to $4.80, the value at 4 cents a pound of the difference in the yields from the two plats, gives $6.90, the gross difference in favor of the meal. If 75 cents is deducted for picking and preparing for market this extra amount of cotton produced by the meal, there still remains $6.15 as a net average profit from the meal plat more than from the seed plat. It must also be remembered that the 40 bushels of seed contained about 25 gallons of oil, worth about $6.50, and approximately 25 pounds of linters, worth at least $1; so that by using the seed as a fertilizer a quantity of two articles of commerce, having a market value of $7.50, was wasted. Considering the relative market value of meal and seed, the increased yield from the meal, and the loss of oil and linters to commerce, there is a difference in this case of $13.65 per acre in favor of using 600 pounds of meal instead of 40 bushels of seed.

TABLE 2.—*Results of tests with 30 bushels of whole cotton seed in comparison with 450 pounds of cotton-seed meal.*

Field used for test.	Fertilizers used.				Yield in seed cotton.		
	Cotton-seed meal.	Cotton seed.	Acid phosphate.	Kainit.	1905.	1906.	Average for the two seasons.
	Pounds.	*Bushels.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Plat 1	450		576	148	2,112	1,343	1,727½
Plat 2		30	576	148	1,809	1,346	1,577½
Difference in yield					303	3	150

In 1904 the land used for these tests produced a crop of cotton of more than a bale an acre. In our experiment it was prepared and cultivated in the usual way. The seed was applied to plat 2 early in the year and the other fertilizers, including the meal for plat 1, were applied at planting time. An application of 576 pounds of acid phosphate and 148 pounds of kainit was made to each plat. In 1905 the meal plat produced 2,112 pounds of seed cotton, 303 pounds more than the seed plat, and in 1906 it produced 1,343 pounds, 3 pounds less than the seed plat. In the average production of the two years there is a difference of 150 pounds in favor of the meal.

The 30 bushels of seed at $16 a ton were worth $7.20, and at $25 a ton the 450 pounds of meal were worth $5.62, or $1.58 less than the seed. This amount, added to $6, the value at 4 cents a pound of the difference in the yields from the two plats, gives $7.58, the gross difference in favor of the meal. If $1 is deducted for picking and preparing for the market the extra quantity of cotton produced by the meal, there is left $6.58 as the net average profit from the meal plat over the seed plat. The oil contained in the 30 bushels of seed was worth about $4.85 and the linters about 75 cents, making approximately $5.60 worth of these products which was wasted. In this test, therefore, there was a difference of $12.18 in favor of using 450 pounds of meal per acre instead of 30 bushels of seed.

TABLE 3.—*Results of tests with 20 bushels of whole cotton seed in comparison with 300 pounds of cotton-seed meal.*

Field used for test.	Fertilizers used.				Yield in seed cotton.		
	Cotton-seed meal.	Cotton seed.	Acid phosphate.	Muriate of potash.	1905.	1906.	Average for the two seasons.
	Pounds.	*Bushels.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Plat 1	300		384	25	1,742	1,133	1,437½
Plat 2		20	384	25	1,615	1,084	1,349½
Difference in yield in favor of meal.					127	49	88

The land used for these tests is the same kind that was used in testing 40 bushels of seed in comparison with 600 pounds of meal. It produced the same crops in 1904 and was prepared in the same way for the crop of 1905. As usual, the seed was applied early in the season, and the other fertilizers at planting time. An application of 384 pounds of acid phosphate and 25 pounds of muriate of potash was made to each plat. In 1905 the meal plat produced 1,742 pounds of seed cotton, 127 pounds more than the seed plat, and in 1906 it yielded 1,615 pounds, 49 pounds more than the seed plat, making an average of 88 pounds more for the two years. The 20 bushels of seed at $16 per ton were worth $4.80, and at $25 per ton the 300 pounds of meal were worth $3.75, or $1.05 less than the seed. This, added to $3.52, the value at 4 cents a pound of the difference in the yields from the two plats, makes $4.57, the gross difference which was realized in favor of the meal. Taking 57 cents from this amount for the cost of picking and preparing for market the extra cotton produced by the meal, we have $4 as the net average profit from the meal plat over the

CONCLUSIONS DRAWN FROM RESULTS OF EXPERIMENTS.

As previously stated, the object of this experiment was to secure data which will enable the growers to estimate how much meal is approximately equivalent to a given quantity of seed in its effect on their crop, and which will guide them in determining what terms they can accept from the mills. Of course, it is impossible to determine what quantity of meal will always be exactly equivalent in effect to a given quantity of seed, as the relative effect will vary with the seasons, some seasons favoring the meal more than the seed, and vice versa. It is believed that the seasons of 1905 and 1906, but especially that of 1906, were more favorable to the seed than to the meal in the vicinity of the experiment, yet the meal plats produced considerably more cotton.

However, the difference between the yields from the corresponding seed and meal plats was much less in 1906 than in 1905. This is attributed to the heavy rainfall of 1906, which was probably less favorable to the meal than to the seed. In these tests 1,000 pounds of meal were used in comparison with 1 ton of seed, and it is evident from the results that less meal would have yielded as much as the seed. It is believed, therefore, that these results amply justify the assumption that 900 pounds of meal is at least equivalent to a ton of seed in effect on the crop; that is, on such land as was used for this experiment.

PROFIT TO GROWERS BY DISPOSING OF SEED.

Statistics show that the average cash price which the mills paid for seed in 1905 was $15.51 per ton, while they sold the meal for $20.35 per ton. At these prices the receipts from a ton of seed would purchase 1,524 pounds of meal. Assuming that 900 pounds of this is equivalent in fertilizing value to 1 ton of seed, the grower who thus disposes of his seed gets 624 pounds of meal, worth $6.95, more than his seed is worth to him per ton. This is figured on a basis of the actual market value of the extra meal obtained, but the results of our experiments clearly indicate that if 1,524 pounds of meal, properly balanced by the necessary amount of acid phosphate and some form of potash, are used as a fertilizer in comparison with a ton of seed to which the necessary acid phosphate and potash have been added, the difference in the resulting profit would certainly be very much greater than the market value of this extra meal, for with this extra meal the growers are enabled at very little extra expense to fertilize their crops much more liberally than if they kept the seed, as the acid phosphate and kainit necessary to properly balance it can be purchased comparatively cheap, and a liberal use of fertilizers almost invariably assures a greater yield and a very much greater profit.

It is very evident that the growers can profitably accept the average terms offered by the mills. Yet many farmers are refusing to do so, and thereby sustain a heavy loss themselves and waste large quantities of oil and linters, which should be turned to profitable uses and increase the wealth of the country. The mills have made large profits, and they should be required to pay for the seed in proportion to the amount of their profits. The growers should get a reasonable portion of the increased value of the seed, and should never dispose of it without getting the equivalent of its fertilizing value plus the cost of hauling it and a reasonable profit on the transaction, which should be proportionate to the market value of the mill products. The cost of hauling varies according to local conditions, but, as a rule, this will not be so great that it will be unprofitable for growers to dispose of their seed on terms by which they realize the equivalent of 1,200 pounds of meal per ton of seed. This, however, is believed to be about the minimum offer which they should accept.

Owing to the increasing value of oil-mill products the mills will no doubt be able to make more favorable terms in the future, or at least will continue to make acceptable terms to the growers for their seed. It is hoped that those growers who underestimate the value of seed and dispose of it without a profit will cease to do this and will hold it for profitable terms, and that those who are refusing profitable terms will see the wisdom of accepting them, not only because of the benefits which they will realize personally, but also because of the immense quantity of valuable products which will be added to the wealth of the country by so doing, which now are being wasted under their present practice of using the whole seed as a fertilizer.

PRESERVATION OF SEED.

There is great necessity for more attention to the proper storing and preservation of cotton seed, as the value of the oil depends upon the condition of the seed when it reaches the mill.

Evidently the products manufactured from the seed would be more useful and more valuable if the seed was kept in good condition. Seed is very easily damaged, especially while green, if stored in large bulks. Large quantities of it reach the mills in very badly damaged condition, thereby causing a great reduction in the value of the products. If the necessary storage room is available, it is very desirable to spread the seed in thin layers over as large a surface as possible, so as to keep it from heating. There is a common practice among growers intending to use their seed for fertilizing purposes to pile it out in the field (fig. 2) as the cotton is ginned and allow it to take the winter's rains. It becomes very hot in these piles and is ruined for oil-mill purposes. While it is intended that seed handled in this way is to be used as a fertilizer, still conditions might arise would make it desirable to let the mills have it. This could done after such treatment. It is, therefore, preferable to ke seed in such condition that any disposition can be made of i seems best at any time during the season. It is also quite that seed kept in this way is damaged to some extent for fert

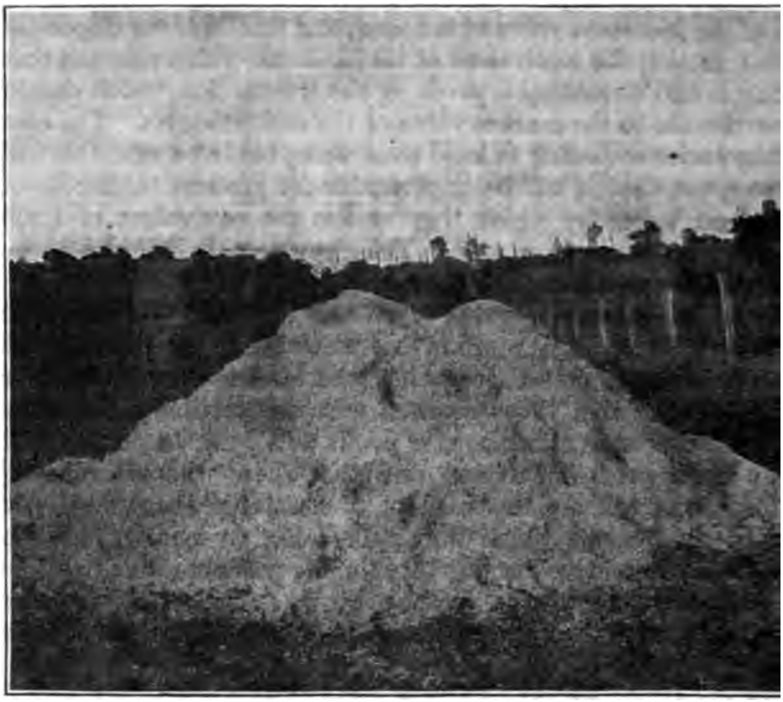


FIG. 2.—Pile of cotton seed retained for fertilizer. (Such piles are commonly seen in the

purposes. So it is evident that this practice should be discont and that greater care should be used in the preservation of the

---

[a] Since this paper was prepared there has been published Bulletin 75 of the Experiment Station, in which are reported results of experiments in the use of ‘ Meal *vs.* Cotton Seed as a Fertilizer'' for cotton. The experiments cover a p two years—1905 and 1906—and the results obtained agree with those reporte Boykin's paper. The conclusion reached is that it is generally a very unwi tice to use cotton seed directly as a fertilizer or as an ingredient of a ferti H. J. WEBBER.

FARMERS' BULLETINS.

The following is a list of the Farmers' Bulletins available for distribution, showing the number, title, and size in pages of each. Copies will be sent free to any address in the United States on application to a Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

22. The Feeding of Farm Animals. Pp. 40.
24. Hog Cholera and Swine Plague. Pp. 16.
25. Peanuts: Culture and Uses. Pp. 24.
27. Flax for Seed and Fiber. Pp. 16.
28. Weeds and How to Kill Them. Pp. 30.
29. Souring and Other Changes in Milk. Pp. 22.
30. Grape Diseases on the Pacific Coast. Pp. 15.
32. Silos and Silage. Pp. 30.
33. Peach Growing for Market. Pp. 24.
34. Meats: Composition and Cooking. Pp. 31.
35. Potato Culture. Pp. 24.
36. Cotton Seed and Its Products. Pp. 16.
39. Onion Culture. Pp. 30.
42. Facts About Milk. Pp. 32.
44. Commercial Fertilizers. Pp. 38.
46. Irrigation in Humid Climates. Pp. 27.
47. Insects Affecting the Cotton Plant. Pp. 32.
48. The Manuring of Cotton. Pp. 16.
49. Sheep Feeding. Pp. 24.
51. Standard Varieties of Chickens. Pp. 48.
52. The Sugar Beet. Pp. 48.
54. Some Common Birds. Pp. 48.
55. The Dairy Herd. Pp. 30.
56. Experiment Station Work—I. Pp. 30.
58. The Soy Bean as a Forage Crop. Pp. 24.
59. Bee Keeping. Pp. 48.
60. Methods of Curing Tobacco. Pp. 24.
61. Asparagus Culture. Pp. 40.
62. Marketing Farm Produce. Pp. 31.
63. Care of Milk on the Farm. Pp. 40.
64. Ducks and Geese. Pp. 55.
65. Experiment Station Work—II. Pp. 32.
66. Meadows and Pastures. Pp. 30.
68. The Black Rot of the Cabbage. Pp. 22.
69. Experiment Station Work—III. Pp. 32.
70. Insect Enemies of the Grape. Pp. 23.
71. Essentials in Beef Production. Pp. 24.
72. Cattle Ranges of the Southwest. Pp. 32.
73. Experiment Station Work—IV. Pp. 32.
74. Milk as Food. Pp. 39.
77. The Liming of Soils. Pp. 24.
78. Experiment Station Work—V. Pp. 32.
79. Experiment Station Work—VI. Pp. 27.
80. The Peach Twig-borer. Pp. 16.
81. Corn Culture in the South. Pp. 24.
82. The Culture of Tobacco. Pp. 22.
83. Tobacco Soils. Pp. 23.
84. Experiment Station Work—VII. Pp. 32.
85. Fish as Food. Pp. 32.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
91. Potato Diseases and Treatment. Pp. 15.
92. Experiment Station Work—IX. Pp. 30.
93. Sugar as Food. Pp. 31.
95. Good Roads for Farmers. Pp. 46.
96. Raising Sheep for Mutton. Pp. 48.
97. Experiment Station Work—X. Pp. 32.
98. Suggestions to Southern Farmers. Pp. 48.
99. Insect Enemies of Shade Trees. Pp. 30.
100. Hog Raising in the South. Pp. 40.
101. Millets. Pp. 30.
102. Southern Forage Plants. Pp. 48.
103. Experiment Station Work—XI. Pp. 30.
104. Notes on Frost. Pp. 24.
105. Experiment Station Work—XII. Pp. 32.
106. Breeds of Dairy Cattle. Pp. 48.
107. Experiment Station Wotk—XIII. Pp. 32.
108. Saltbushes. Pp. 20.
109. Farmers' Reading Courses. Pp. 20.
110. Rice Culture in the United States. Pp. 28.
111. Farmer's Interest in Good Seed. Pp. 24.
112. Bread and Bread Making. Pp. 40.
113. The Apple and How to Grow It. Pp. 32.
114. Experiment Station Work—XIV. Pp. 28.
115. Hop Culture in California. Pp. 28.
116. Irrigation in Fruit Growing. Pp. 48.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 30.
120. Insects Affecting Tobacco. Pp. 32.
121. Beans, Peas, and other Legumes as Food. Pp. 38.
122. Experiment Station Work—XVI. Pp. 32.
124. Experiment Station Work—XVII. Pp. 32.
125. Protection of Food Products from Injurious Temperatures. Pp. 24.
126. Practical Suggestions for Farm Buildings. Pp. 48.
127. Important Insecticides. Pp. 46.
128. Eggs and Their Uses as Food. Pp. 40.
129. Sweet Potatoes. Pp. 40.
131. Household Tests for Detection of Oleomargarine and Renovated Butter. Pp. 10.
132. Insect Enemies of Growing Wheat. Pp. 38.
133. Experiment Station Work—XVIII. Pp. 32.
134. Tree Planting in Rural School Grounds. Pp. 32.
135. Sorghum Sirup Manufacture. Pp. 40.
136. Earth Roads. Pp. 24.
137. The Angora Goat. Pp. 48.
138. Irrigation in Field and Garden. Pp. 40.
139. Emmer: A Grain for the Semiarid Regions. Pp. 16.
140. Pineapple Growing. Pp. 48.
142. Principles of Nutrition and Nutritive Value of Food. Pp. 48.
143. Conformation of Beef and Dairy Cattle. Pp. 44.
144. Experiment Station Work—XIX. Pp. 32.
145. Carbon Bisulphid as an Insecticide. Pp. 28.
146. Insecticides and Fungicides. Pp. 16.
147. Winter Forage Crops for the South. Pp. 40.
149. Experiment Station Work—XX. Pp. 32.
150. Clearing New Land. Pp. 24.
151. Dairying in the South. Pp. 48.
152. Scabies in Cattle. Pp. 32.
153. Orchard Enemies in the Pacific Northwest. Pp. 39.
154. The Home Fruit Garden: Preparation and Care. Pp. 16.
155. How Insects Affect Health in Rural Districts. Pp. 19.
156. The Home Vineyard. Pp. 22.
157. The Propagation of Plants. Pp. 24.
158. How to Build Small Irrigation Ditches. Pp. 28.
159. Scab in Sheep. Pp. 48.
161. Practical Suggestions for Fruit Growers. Pp. 30.
162. Experiment Station Work—XXI. Pp. 32.
164. Rape as a Forage Crop. Pp. 16.
165. Silkworm Culture. Pp. 32.
166. Cheese Making on the Farm. Pp. 16.
167. Cassava. Pp. 32.
168. Pearl Millet. Pp. 16.
169. Experiment Station Work—XXII. Pp. 32.
170. Principles of Horse Feeding. Pp. 44.
172. Scale Insects and Mites on Citrus Trees. Pp. 43.
173. Primer of Forestry. Pp. 48.
174. Broom Corn. Pp. 30.
175. Home Manufacture and Use of Unfermented Grape Juice. Pp. 16.
176. Cranberry Culture. Pp. 20.
177. Squab Raising. Pp. 32.
178. Insects Injurious in Cranberry Culture. Pp. 32.
179. Horseshoeing. Pp. 30.
181. Pruning. Pp. 39.
182. Poultry as Food. Pp. 40.

183. Meat on the Farm: Butchering, Curing, and Keeping. Pp. 37.
184. Marketing Live Stock. Pp. 40.
185. Beautifying the Home Grounds. Pp. 24.
186. Experiment Station Work—XXIII. Pp. 32.
187. Drainage of Farm Lands. Pp. 38.
188. Weeds Used in Medicine. Pp. 45.
190. Experiment Station Work—XXIV. Pp. 32.
192. Barnyard Manure. Pp. 32.
193. Experiment Station Work—XXV. Pp. 32.
194. Alfalfa Seed. Pp. 14.
195. Annual Flowering Plants. Pp. 48.
196. Usefulness of the American Toad. Pp. 16.
197. Importation of Game Birds and Eggs for Propagation. Pp. 30.
198. Strawberries. Pp. 24.
199. Corn Growing. Pp. 32.
200. Turkeys. Pp. 40.
201. Cream Separator on Western Farms. Pp. 23.
202. Experiment Station Work—XXVI. Pp. 32.
203. Canned Fruits, Preserves, and Jellies. Pp. 32.
204. The Cultivation of Mushrooms. Pp. 24.
205. Pig Management. Pp. 40.
206. Milk Fever and Its Treatment. Pp. 16.
208. Varieties of Fruits Recommended for Planting. Pp. 48.
209. Controlling the Boll Weevil in Cotton Seed and at Ginneries. Pp. 32.
210. Experiment Station Work—XXVII. Pp. 32.
211. The Use of Paris Green in Controlling the Cotton Boll Weevil. Pp. 23.
213. Raspberries. Pp. 38.
215. Alfalfa Growing. Pp. 40.
216. The Control of the Boll Weevil. Pp. 32.
217. Essential Steps in Securing an Early Crop of Cotton. Pp. 16.
218. The School Garden. Pp. 40.
219. Lessons from the Grain Rust Epidemic of 1904. Pp. 24.
220. Tomatoes. Pp. 32.
221. Fungous Diseases of the Cranberry. Pp. 16.
222. Experiment Station Work—XXVIII. Pp. 32.
223. Miscellaneous Cotton Insects in Texas. Pp. 24.
224. Canadian Field Peas. Pp. 16.
225. Experiment Station Work—XXIX. Pp. 32.
226. Relation of Coyotes to Stock Raising in the West. Pp. 24.
227. Experiment Station Work—XXX. Pp. 32.
228. Forest Planting and Farm Management. Pp. 22.
229. The Production of Good Seed Corn. Pp. 24.
231. Spraying for Cucumber and Melon Diseases. Pp. 24.
232. Okra: Its Culture and Uses. Pp. 16.
233. Experiment Station Work—XXXI. Pp. 32.
234. The Guinea Fowl. Pp. 24.
235. Preparation of Cement Concrete. Pp. 32.
236. Incubation and Incubators. Pp. 32.
237. Experiment Station Work—XXXII. Pp. 32.
238. Citrus Fruit Growing in the Gulf States. Pp. 48.
239. The Corrosion of Fence Wire. Pp. 32.
240. Inoculation of Legumes. Pp. 8.
241. Butter Making on the Farm. Pp. 32.
242. An Example of Model Farming. Pp. 16.
243. Fungicides and their Use in Preventing Diseases of Fruits. Pp. 32.
244. Experiment Station Work—XXXIII. Pp. 32.
245. Renovation of Worn-out Soils. Pp
246. Saccharine Sorghums for Forage.
247. The Control of the Codling Moth a Scab. Pp. 21.
248. The Lawn. Pp. 20.
249. Cereal Breakfast Foods. Pp. 36.
250. The Prevention of Wheat Smut a Smut of Oats. Pp. 16.
251. Experiment Station Work—XXXI
252. Maple Sugar and Sirup. Pp. 36.
253. The Germination of Seed Corn. P
254. Cucumbers. Pp. 30.
255. The Home Vegetable Garden. Pp.
256. Preparation of Vegetables for t Pp. 48.
257. Soil Fertility. Pp. 39.
258. Texas or Tick Fever and Its Pr Pp. 45.
259. Experiment Station Work—XXXV
260. Seed of Red Clover and Its Impuri 24.
261. The Cattle Tick. Pp. 22.
262. Experiment Station Work—XXXV
263. Practical Information for Beginne gation. Pp. 40.
264. The Brown-tail Moth and How to Pp. 22.
265. Game Laws for 1906. Pp. 54.
266. Management of Soils to Conserve Pp. 30.
267. Experiment Station Work—XXX 32.
268. Industrial Alcohol: Sources and ture. Pp. 45.
269. Industrial Alcohol: Uses and Stati 29.
270. Modern Conveniences for the Far Pp. 48.
271. Forage Crop Practices in Wester and Western Washington. Pp.
272. A Successful Hog and Seed-Corn F 16.
273. Experiment Station Work—XXX 32.
274. Flax Culture. Pp. 36.
275. The Gipsy Moth and How to C Pp. 22.
276. Experiment Station Work—XXXI
277. The Use of Alcohol and Gasoline Engines. Pp. 40.
278. Leguminous Crops for Green Manu 27.
279. A Method of Eradicating Johnson G 16.
280. A Profitable Tenant Dairy Farm.
281. Experiment Station Work—XL.
282. Celery. Pp. 36.
283. Spraying for Apple Diseases and th Moth in the Ozarks. Pp. 42.
284. Insect and Fungous Enemies of East of the Rocky Mountains.
285. The Advantage of Planting Heav Seed. Pp. 16.
286. Comparative Value of Whole C and Cotton-Seed Meal in Fertil ton. Pp. 14.
287. Poultry Management. (In press.)
288. Nonsaccharine Sorghums. Pp. 28.
289. Beans. Pp. 28.

O

Issued June 29, 1907.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 287.

POULTRY MANAGEMENT.

BY

G. ARTHUR BELL,

Assistant Animal Husbandman, Bureau of Animal Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., March 11,

Sir: I have the honor to transmit herewith, and to recomm publication as a Farmers' Bulletin, a paper on Poultry Mana prepared by G. Arthur Bell, Assistant Animal Husbandman Bureau, being a condensation of an article written for the second Annual Report of the Bureau. The paper is confined to the chicken industry, as it was found that to treat thorou phases of poultry raising would make a bulletin of undue and, furthermore, turkeys, ducks, geese, guinea fowls, e covered in a satisfactory manner by other publications of the ment.

The bulletin has been prepared from the practical standpoi technicalities have been avoided as much as possible. In all the effort has been made to bring the discussion of meth appliances down to date, including such subjects as dry curtain-front houses, colony houses, etc. The author has ha tical experience in the poultry business since early boyhood as exhibitor, and judge, and during the past two years he has many successful poultry farms in the East. The methods some of these farms are described, and some of the houses an ances are illustrated.

Acknowledgments are made to Prof. J. E. Rice, of the University Experiment Station; Mr. F. H. Stoneburn, Wa N. Y.; Prof. G. M. Gowell, of the Maine Agricultural Exp Station, and Prof. W. P. Brooks, of the Massachusetts Experiment Station, for information and courtesies. The press has also been very courteous, and the cooperation o successful poultry raisers throughout the country has been value. Mr. Rob R. Slocum, Poultry Assistant in the Anim bandry Office of this Bureau, who entered the service after the work on the original article was completed, has assisted in preparing the section on poultry diseases.

This bulletin will supersede Farmers' Bulletin 41 ("Fowl and Feeding") and 141 ("Poultry Raising on the Farm").

Respectfully,

A. D. Melvin,
Chief of Bu

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

	Page.
Making a start with poultry	5
Classification	5
Egg breeds	5
Meat breeds	6
General-purpose breeds	6
Ornamental breeds	6
Houses and inclosures	6
Systems of housing	6
Location and construction of houses	7
Interior arrangements	10
Yards	12
Some successful houses	12
Continuous houses	12
Colony houses	17
Management of hens for egg production	19
Systems of feeding	20
Dry feeding	20
Mash feeding	21
Miscellaneous feeds	22
Grit and other substances	24
Methods of feeding	25
Frequency of feeding	25
Amount of feed	25
Importance of a varied ration	26
Effect of feed on character of egg	26
The droppings as an indication of health	26
Molting	26
Exercise	27
Age of birds for profitable egg production	27
Raising chickens	27
Number of females to one male	28
Hatching chicks	28
Eggs for hatching	28
Hatching chicks with hens	29
Incubators and brooders	30
Feeding and care of chicks	31
Broilers, roasters, and capons	34
Broilers	34
Roasters	34
Capons and caponizing	35
Fattening poultry	36
Pen fattening	36
Crate fattening	36
Machine cramming	37
Hand cramming	37
Feed for fattening	38

Page.
Marketing poultry and poultry products 38
- Killing, dressing, and packing poultry 38
- Shipping live poultry 39
- Sorting, packing, and shipping eggs 40
- Testing eggs 40
- Methods of selling 40

Preserving eggs 41
Diseases, bad habits, and insect pests 42
- Importance of cleanliness 42
- Diseases 42
- Bad habits 47
- Insect pests 47

ILLUSTRATIONS.

Page.
Fig. 1. Row of nests for laying hens 11
2. Feed trough 11
3. A continuous apartment house 13
4. Interior of a New York poultry house, showing duck-covered window 13
5. Curtained roosts and hinged nest boxes 14
6. A curtain-front house 15
7. A Connecticut poultry ranch 16
8. Laying house and open range 17
9. A colony house 18
10. "New Hampshire" form of poultry house 19
11. Nest for a sitting hen 29
12. A-shaped coop for hen and chickens 29
13. Box coop for hen and chickens 30
14. Cramming machine in operation 37

POULTRY MANAGEMENT.

MAKING A START WITH POULTRY.

The safest way for those who are about to make their first attempt at poultry raising is to start in a small way with a few fowls, and learn the business thoroughly before making large investments. Mistakes will be made and many difficult problems will be presented for solution before success in any large measure will be attained. As soon as it is found to be a paying investment, more capital may be put into the plant.

Another good plan for the beginner who wishes to learn the art of poultry keeping is to secure a position with some successful poultryman. One or two years of work on a large, practical plant will be found a great help, as the methods of caring for the birds and of marketing the products can thus be learned better than in almost any other way.

The question is often asked as to what is the best time of the year for one to begin. When to begin is not very important, but the fall of the year is a good time, for then stock can be purchased for less money than at any other season. It is also advisable that the fowls be moved to their new quarters before they begin to lay.

If the beginner has had experience in poultry keeping, it will be all right to purchase eggs, otherwise he should begin with the fowls and thus gain some knowledge of caring for poultry before attempting to raise chickens.

CLASSIFICATION.

For convenience, chickens may be classified as egg breeds, meat breeds, general-purpose breeds, and fancy or ornamental breeds.

EGG BREEDS.

The egg breeds include the small or medium-sized fowls which are very active, quick to mature, producers of white-shelled eggs, usually nonsitters or at best but poor sitters, and rather poor mothers. The various varieties of Leghorns and Minorcas are good representatives of this class. Because they are poor sitters some other breed, or at least a few other fowls, should be kept if natural methods of incubation are to be employed. On account of their early maturity it is not uncommon for individuals to begin laying at the age of four and one-half months. As mentioned above, these breeds are very active and do not fatten as readily under ordinary conditions as the larger and less active breeds. The fowls of this class have large combs and wattles, which make them rather sensitive to low temperatures.

MEAT BREEDS.

The largest fowls are represented in this class, and these breeds are especially suitable for the production of large roasters. They are slow and somewhat sluggish in movement, with little desire for foraging, easily confined by low fences, rather slow to mature, persistent sitters, and rather indifferent layers of large brown-shelled eggs. Many poultrymen, however, are getting very good egg yields from them. The Brahmas, Cochins, and Langshans may be mentioned as belonging to this class.

GENERAL-PURPOSE BREEDS.

This class includes fowls which are of fair size and which will also produce a good quantity of brown-shelled eggs, making them especially adapted to the person wishing a supply of both eggs and meat. As one has to make frequent sales of flesh in the shape of surplus cockerels and hens, the carcass as well as egg production should be considered. The general-purpose breeds are usually good sitters and good mothers. They have medium-sized combs and wattles and endure cold weather well. They occupy a medium position between the egg and meat breeds as to size, egg production, and docility. The Plymouth Rocks, Wyandottes, Orpingtons, and Rhode Island Reds are good representatives of this class.

ORNAMENTAL BREEDS.

As a rule the breeds in this class are not so well adapted for farm purposes as are the breeds of the other three classes. The Polish, Exhibition Games, Silkies, Sultans, Frizzles, and Bantams are representative ornamental breeds.

A full description of the various varieties of fowls is given in Farmers' Bulletin No. 51, " Standard Varieties of Chickens."

HOUSES AND INCLOSURES.

SYSTEMS OF HOUSING.

In the manner of housing fowls we have two systems widely different in their extremes. At one extreme is the colony plan, shown in figure 7 (p. 16), which consists in placing small houses for small flocks far enough apart to obviate the necessity of fences, thus giving free range with but little mingling of the different flocks. At the other extreme, we have the continuous apartment house shown in figures 3 and 6 (pp. 13 and 15). This kind of house consists of a series of separate pens, under one roof, opening directly into a hall way in the rear, or having doors between the pens without the hall way, or opening into a hall way and also into one another. There are several plans and arrangements between these two extremes which may be built to suit varying conditions.

The advantages of the colony plan are—first, small flocks on free range; second, no expense for fencing; third, there is less need for scrupulous attention to cleanliness and providing regular supplies of animal and vegetable feed during summer months. This plan, however, has the following disadvantages: First, extra cost of labor in caring for fowls in stormy weather, when it will often be difficult to get around to feed and care for the fowls regularly; second, houses built on the colony plan, if built as well, cost more than a continuous house of the same capacity, for partitions, which may be constructed largely of wire netting, are much cheaper than two end walls; third, the colony plan allows but about 100 birds per acre, while the continuous-house system, with suitable yards, allows 450 to 500 birds per acre.

LOCATION AND CONSTRUCTION OF HOUSES.

Location of buildings.—The first consideration is a suitable location for the poultry house or houses. If possible, it is best to select an elevation having a natural drainage away from the building, for damp ground means cold ground. If the house can be built in the lee of a wind-break or a hill, or in front of farm buildings, so much the better. A dry, porous soil, such as sandy or gravelly loam, is preferable to a clay soil, for the former is more easily kept in a sanitary condition. If it is impracticable to select a soil that is naturally dry, the soil should be made dry by thorough underdrainage. A purely sandy soil should not be selected, for a soil not good enough to support plant life is unfit for poultry.

As sunlight and warmth are essential to success, the buildings should face the south; other things being equal they will be warmer and drier. When a direct southern exposure can not be obtained a southeastern is preferable to a southwestern exposure, for fowls seem to prefer morning to afternoon sun. A gentle slope facing the south is the most suitable.

When to build.—It is best to build the houses during the spring or early summer, for then they have time to dry out during the hot days. Lumber is often rather damp and should be thoroughly dried out before winter. Cement floors and foundation walls will also have an opportunity to dry thoroughly, and thus may be avoided much of the dampness so often attributed to them.

Size and dimensions of house.—The size of the building required will depend largely on the number of fowls to be kept and on the size of the flocks. From 40 to 50 seems to be about as many as is safe and economical to keep together. With flocks of this size about 5 square feet of floor space should be allotted to each bird, which will suffice in most cases where careful attention is given to cleanliness and ventilation. If the fowls are kept in smaller flocks more floor space per bird will be needed. Where the climate is so mild that it is unnecessary to keep the fowls confined, except for a few days at a time, less space per bird will be sufficient. The smaller breeds, being more active and restless, require about as much room as the larger breeds.

For the greatest amount of floor space for the least cost, a building should be square, for, other things being equal, the nearer square a house is the less lumber it will take. It is, however, out of the question to have a large house built square.

The building should not be so wide that the sun can not reach the back of the house, otherwise it will be damp. Fourteen feet is a convenient width if there are no alleyways.

The house should be built as low as possible without danger of the attendants bumping their heads against the ceiling. A low house is more easily warmed than a high one.

Foundation walls.—When permanent houses are to be built it is usually most economical to erect them on foundations made of brick, stone, or concrete. These should be built deep enough to prevent heaving by frost and high enough to prevent surface water from entering. Where large stones or bricks are not readily available good walls may be made from small stones. In case none of these foundation materials is available the building may be erected on posts.

The roof.—There are three general styles of roofs—the single pitch, shown in figure 9 (p. 18); the gable roof, or double pitch with equal sides, shown in figure 3 (p. 13), and the combination, with one long and one short pitch, shown in figure 6 (p. 15).

The single-pitch roof is the easiest to build. It gives the highest vertical front exposed to the sun's rays and throws all the rain water to the rear; but in order to have the back wall of sufficient height to allow a person to work conveniently in the rear portion of the house it is necessary to have the front wall very high—unless a very slight pitch is used—which requires much more lumber for the front side than in the case of the other two styles. The gable roof provides for a garret space, which may be filled with straw, thus helping to make t house warm and dry.

It takes the same amount of material to build any one of the roofs mentioned if the pitch of the roof and the ground plan are similar. Most roofs can be one-fourth pitch. Shingle roofs, however, should generally be one-third pitch. In any case the steeper the pitch the greater will be the cost of roofing and the longer the roof will last.

There are several prepared roofing materials which are good, or the roof may consist of matched lumber or shingles.

Floors.—The floor may be of earth, wood, or cement. It is important that the floor be dry, otherwise it will be impossible to keep litter on the floor fit for use. Straw and similar material gathers moisture, and when the litter becomes damp enough to be limp it is practically useless for fowls to scratch in for their grain feed.

Earth floors are excellent, provided they are kept dry. Except in very dry climates, however, they are apt to be damp. Where an earth floor is used it should be 3 or 4 inches above the level of the ground outside. An objection to earth floors is the difficulty of cleaning them, for it is usually necessary to remove 2 or 3 inches of the top and to replace this with fresh soil, and even then one can not be certain that all of the droppings have been removed.

Board floors are usually short-lived unless air is allowed to circulate under them. This may be provided for by means of openings in the foundation walls, which should be closed during the winter months. A board floor covered with one-fourth inch of fine sand, with scratching material on this, makes a good floor. The litter and sand can be readily removed when desired and fresh materials provided. If the wooden floors are constructed within 2 or 3 inches of the ground it is essential that the foundation walls be constructed in such a way that rats can not gain access beneath the floor.

A good cement floor is the best, for it is easily cleaned and very durable. It should be covered with one-fourth or one-half inch of fine soil or sand and plenty of litter. In constructing this floor the ground should be excavated to the depth of 3 or 4 inches and then filled in with small stones or coarse gravel to make a good foundation. Cover with about 2 inches of mortar, made by mixing thoroughly, while dry, one part of good cement to three or four parts of sand, and then wetting with water and mixing thoroughly.

Further details regarding the construction of cement floors are given in Farmers' Bulletin No. 235, "Cement Mortar and Concrete."

Windows.—Too much glass makes a house cold at night and during the winter months and warm during the summer days. One square foot of glass surface should be allowed to about 16 or 18 square feet of floor space. The windows should be placed high and vertical rather than horizontal, for if the windows are placed low the sunlight will not reach the rear portions of the floor space, except during the winter when the sun is lowest. An 8 by 10 inch glass is a good-sized light used in a 12-light sash, making the sash about 3 feet 10 inches by 2 feet 5 inches. A 10 by 12 inch glass is another good-sized light to be used in an 8-light sash, making the sash about 4 feet 5 inches by 2 feet. Use two of these sashes for a house having about 250 square feet of floor space. In the coldest parts of the United States it is well to double glaze the windows, leaving one-fourth or one-half inch space between the glass.

Quality of construction.—It is not necessary to build expensive houses, but they should be serviceable, fairly roomy, well lighted, and well ventilated without drafts. The house should be built with a view to simplicity, economy, and convenience, and should be constructed according to the location and climatic conditions.

The walls may consist of (1) one thickness of boards, matched or unmatched; (2) one thickness of boards, matched or unmatched, covered with one or two thicknesses of building paper or roofing; (3) one thickness of boards covered with paper, then shingled or covered with lapped siding or matched lumber, making a solid double wall; (4) double boards with dead air space between; (5) double boards with space between filled with straw, hay, or other similar material. The second and third methods are the most common.

Interior Arrangements.

As far as possible interior fixtures should be so constructed as to permit them to be readily removed and cleaned.

Roosts.—A 2 by 3 inch scantling set edgewise with the upper edge slightly rounded makes a satisfactory perch. Allow 7 to 10 inches for each fowl; that is, a perch 16 feet long would furnish room enough for 20 fowls. A smooth platform should be placed under the perches to catch the droppings. The perches should be from 6 to 10 inches above this platform so as to allow the droppings to be removed without removing the perches. It is usually desirable to have the platform some distance from the floor, from 2 to 3 feet, in order that all the floor space may be available. If the roosts are located at the rear of the building it is possible to reduce the size of the roosting apartments at night by having a curtain swung from the ceiling which may be hung up against the ceiling during the day. A curtain of heavy unbleached muslin or duck tacked to a light wooden frame will be found very useful on cold nights in the Northern States.

Nests.—The nests should be situated in a more or less dark place, for then the hens will be less apt to eat the eggs. A good place is directly beneath the roost platform, with the nests so arranged that the hen enters from the side toward the wall. Each nest should be from 12 to 14 inches square, and high enough (about 12 or 14 inches) to be convenient for the hen to enter. The partitions between the nests should be high enough to prevent the hens from rolling the eggs from one nest to another, and low enough to permit hens to go from one nest to another, otherwise they will fight and eggs will be broken. Fine hay or straw makes a good nesting material.

Dust boxes.—Chickens never wash, as many other birds do, but cleanse themselves of insects by wallowing in soil. Where board or cement floors are used, some means for dusting should be provided during the winter months. For a flock of 50 to 60 fowls a dust box 3 by 5 feet or 4 by 4 feet will be found large enough in most instances, and should be placed where it can be reached by sunlight during as much of the day as possible. Fine, light, dry dust is the best, but sandy loam is good. Road dust is recommended by many, but it is apt to be filthy. Coal or wood ashes may be mixed with the soil if desired.

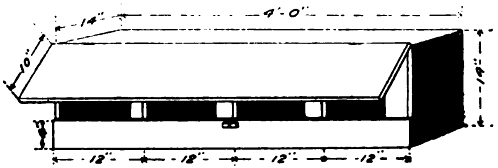


FIG. 1.—Row of nests for laying hens.

Drinking fountain.—The water receptacle should be large enough to hold plenty of water to last twenty-four hours, so that the fowls will never suffer for the lack of water, and should be elevated a little above the floor to prevent the water from becoming dirty, as it would otherwise. Drinking vessels should be carefully rinsed when fresh water is given.

Feed trough and grit boxes.—In figure 2 is shown an easily and cheaply constructed feed trough, which is so constructed that the fowls can not get into it with their feet and soil the feed.

Several small boxes for shell, grit, beef scraps, etc., should be fastened against the wall at a convenient distance (12 to 16 inches) above the floor, where the fowls can have constant access to them.

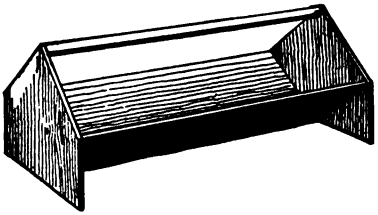


FIG. 2.—Feed trough.

Ventilation.—As it is better to have a cold dry house than a warm damp one, some means of ventilation should be provided. There is no better way to ventilate than by opening doors and windows as much or little as weather conditions require, but in all cases care should be taken to avoid any drafts. A cloth curtain over an opening has proved a very successful method of ventilation.

YARDS.

If convenient, it is well to have double yards, for then one may rotate green crops. The yards may be sown to clover, rye, bluegrass, etc., and while the fowls are using one yard the green feed in the other is getting a fresh start.

If the yards are to be on only one side of the house, they should be on the south side in order that the fowls may have the benefit of the first dry ground in early spring. It not infrequently happens that in localities where snow is abundant the ground on the south side is dry many days before that on the north side.

If the yards are to be in permanent sod and are to furnish green feed for the fowls, 70 to 80 square feet should be allowed for each bird. If part of the green feed is to be otherwise provided for, and the yards used mainly for exercise grounds, 35 to 40 square feet per bird will be sufficient.

Wire netting, 2-inch mesh, is suitable for fencing and can be bought cheaply. Where several runs are adjoining, the fences must be boarded up at the bottom to a height of 2 to 2½ feet to prevent the males fighting with one another. Height of fences will need to be regulated by the variety of fowls. The heaviest breeds, like the Brahmas, may be restrained by a 4-foot fence, while most of the other breeds can be kept in by a 6-foot fence. Some of the Hamburgs and Leghorns, however, need an 8-foot or 10-foot fence. Gates should be provided in order to permit access from one yard to the next.

Shade of some kind should be provided, and this can often be advantageously furnished by planting fruit trees (such as pear, plum, cherry, and apple) in the yard.

SOME SUCCESSFUL HOUSES.

In the preceding pages some of the important principles of house construction and of the internal arrangements of the house have been given, leaving it to the individual to choose the kind of house best adapted to his purpose. There is no one house which is best for all locations and for all purposes. In the following pages some descriptions of practical houses in actual use are given. Some of these houses are expensive and others are cheap. It is impossible to give an approximate cost of any house for all sections of the country, because the cost of material and labor varies so greatly.

Continuous Houses.

In figure 3 is shown a long continuous house in use at the White Leghorn Poultry Yards, in New York State. It is 250 feet long by 16 feet wide and 7 feet high at the eaves. Along the north side is a 4-foot passageway, which is separated from the pens by a matched-board partition. The house, exclusive of this passageway, is divided into 20 pens 12 by 12 feet and a feed room 10 by 12 feet. A door opens from the passageway into each pen, and there is also a door in each partition between the pens. These partitions consist largely of wire netting, but all are boarded up to a height of 2½ feet from the floor, in order that males in the adjoining pens may not fight through the wire, and thus injure each other. Several of the partitions in the house are boarded up solidly from floor to ceiling to prevent the drafts which are so likely to be found in long houses.

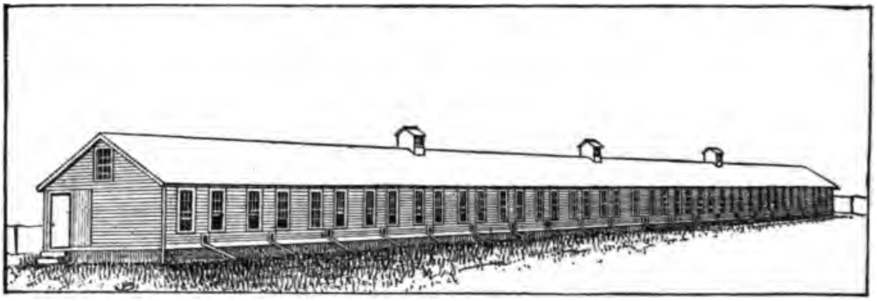


FIG. 3.—A continuous apartment house.

In the front or south side of each pen are placed two windows, each window consisting of two 12-light sashes. The windows are arranged to slide up and down as in an ordinary dwelling, special care being exercised to have them move freely in order that they may be opened at any time, regardless of weather conditions. Unless this point is considered the windows are very apt to become frozen in on the arrival of cold weather, and it becomes difficult to open them, hence the ventilation is frequently neglected. During the past winter one window in each pen was arranged as shown in figure 4, the upper sash being dropped to the window sill and the opening thus made covered with a piece of 8-ounce duck, the latter being tacked to the upper bar of the lower sash and to the sides and top of the window frame. In extreme cold

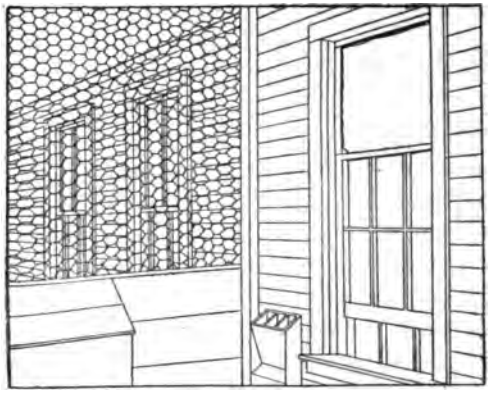


FIG. 4.—Interior of a New York poultry house, showing duck-covered window.

weather the lower sash is slipped up to the top of the window, thus effectually closing it. This method proved to be very satisfactory, the house being unusually dry and the birds appearing to be in excellent health.

The roosting platform (see fig. 5) is placed in the rear of each pen, and at the front of each platform is hung a duck curtain operated by means of cords run through rings attached to the ceiling. This additional protection effectually prevents the freezing of Leghorn combs in all except the most severe winter weather. The nests are directly under the platforms and are entered from the rear. The bottoms of the nests are attached to one side by means of hinges and are held in place by a number of hasps. To clean the nests it is simply necessary to unfasten the hasps and the entire bottom swings downward.

The floor consists of matched boards. The outside of the studs of the walls are first boarded, then covered with paper and clapboarded. The inside of the studs is covered with matched boards, making a 4-inch dead air space between the two walls. The ceilings are made of matched boards. Over each pen in the ceiling is a trapdoor about 20 by 24 inches opening into the attic. At each end of the attic is a window, and at regular intervals along the peak of the roof are ventilating cupolas. Straw may be placed in the attic, thus providing an effective means of absorbing the moisture.

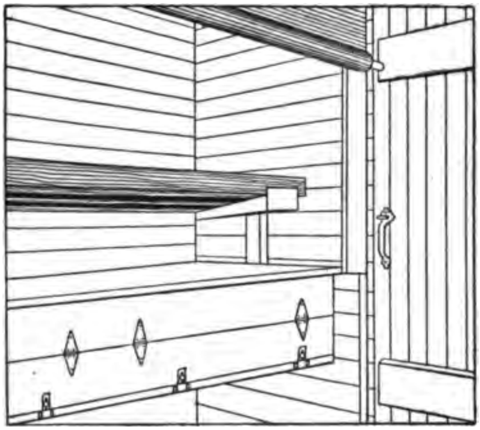


FIG. 5.—Curtained roosts and hinged nest boxes.

In figure 6 is shown one of the curtain-front houses in use at the Maine Experiment Station. Fresh air has been a big consideration in the building of this house, which has a curtained front to the house proper and a curtain-front roosting room. Professor Gowell, expert in charge of poultry raising at this station, has found this method of ventilation very satisfactory.

The building is 120 feet long and 16 feet wide. The front wall is 6¾ feet and the rear wall 5½ feet high from the floor to the top of the plate. The roof is of unequal span, the ridge being 4 feet in from the front wall, and the height of the ridge above the floor is 9 feet. The sills are 4 by 6 inches and rest on a rough stone wall. The floor, consisting of two thicknesses of hemlock boards, rests on 2 by 8 inch timbers, which are placed 2 feet apart. The rest of the frame of the building consists of 2 by 4 inch material. The building is boarded, papered, and shingled on both roof and walls, and in addition the rear wall and 4 feet of the lower part of the rear roof are ceiled on the inside of the studding and the space packed with dry sawdust. Outside of the building a 3-foot platform extends across the ends and along the front.

The house is divided into four 30 by 16 foot pens. In the front side of each pen are two 12-light windows and a door 2½ feet wide. The space between the window and door comes close up to the eaves, leaving an unbroken front 3 feet high below the eaves. The opening is 3 by 14 feet and is covered by a wooden frame, covered with 10-ounce duck. This curtain is hinged at the top and is swung in when opened, and it is always kept open, except on stormy days and winter nights. Each pen is of suitable size to accommodate 100 fowls, thus allotting 4.8 square feet of floor space to each bird.

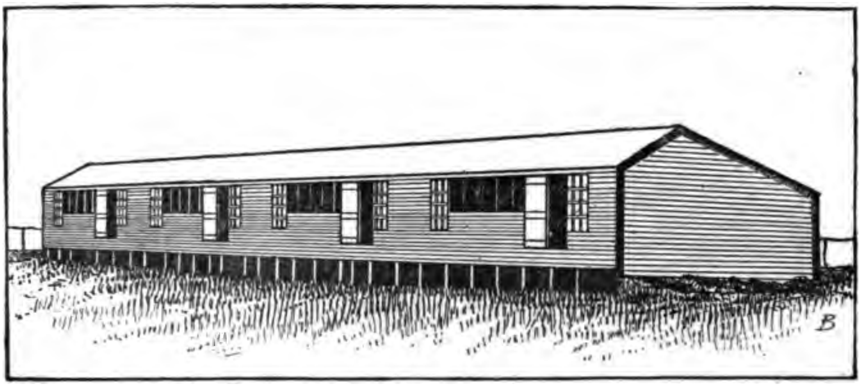


FIG. 6.—A curtain-front house.

A roost platform 4 feet 10 inches wide and 3 feet above the floor extends along the rear side for the entire 30 feet. Three perches of 2 by 3 inch material are placed on edge 10 inches above the platform. The rear perch is 11 inches out from the wall, and the space between the perches is 16 inches, which leaves 15 inches between the front perch and the duck curtain. The two curtains in front of the roost are each 15 feet long and 30 inches wide. They are hinged at the top, and open out into the room and fasten up when not in use.

At one end of each pen are placed 12 trap nests and 8 at the other end. Several small boxes are placed against the wall 1½ feet above the floor for shell, grit, bone, etc. The doors between the pens are wooden frames covered with 10-ounce duck and are hung with double-action spring hinges, so as to open in either direction. Tight board partitions are used between the pens to avoid drafts.

The chief point about this house is that only two cloth curtains are between the birds and the night air, it being located in a cold climate where the mercury often falls considerably below zero in winter. The floor is covered to the depth of 6 or 8 inches with straw, and some grain scattered in the litter early in the morning induces the birds to exercise as soon as they leave the roost. It would be unwise to open the curtains of the roosting pen and let the birds into the cold atmosphere of the room without some inducement to work.

In figure 7 are shown the houses of Mr. Tillinghest's plant in Connecticut. Each house is 10 by 20 feet, 4 feet high at the eaves, and 6½ feet at the center. The whole construction, including the roof, is of 1-inch cypress boards, matched. The floors consist of earth, and are not found damp, owing, no doubt, to the excellent natural drainage. The only fixture in each of these houses is a hopper having a capacity of about 1½ bushels for wheat screenings, a small hopper for beef scraps, and 4 or 5 soap boxes for nests. In the rear of the house are placed 3 or 4 perches about 3 feet from the ground. No board for droppings is used.

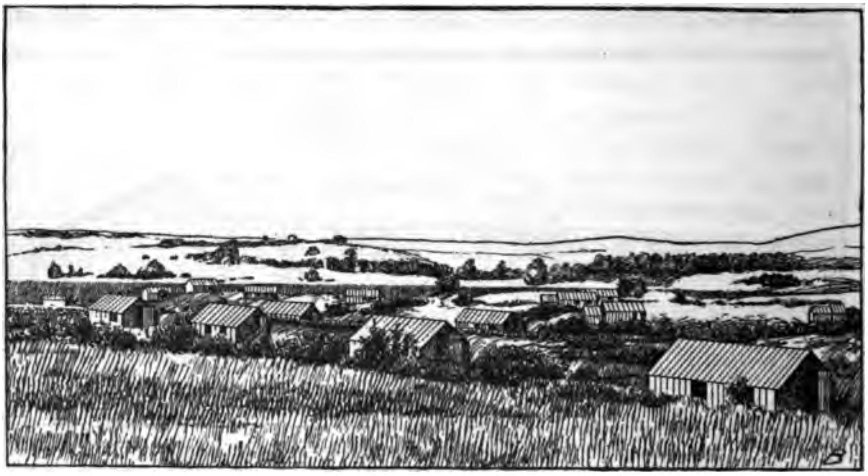


FIG. 7.—A Connecticut poultry ranch. Note arrangement of colony houses, which does away with necessity of fences.

The great point at this plant is the simplicity and economy of labor in caring for the birds. Nature has greatly aided the owner by providing not only excellent drainage, but also a fine stream, which furnishes plenty of water and serves as a natural fence. The elevated ground abounds with wild berries, and insects are usually plentiful during the summer.

The supply of grain in summer consists of wheat screenings fed from self-feeding hoppers, which are usually filled but once a week. A small quantity of beef scraps is fed in the afternoon, when the eggs are gathered. The fowls get their supply of water by going to the creek in both winter and summer. In winter a little cracked corn is added to the wheat screenings, and beef scraps are accessible to the fowls at all times.

Figure 8 shows one of the winter laying houses at H. J. Blanchard's farm, in New York State. This building is 40 feet long and 16 feet wide, the distance from the floors to the eaves being 7 feet. The walls are double, with a 4-inch space filled with straw. On the south side are 6 double-glazed sashes, which make a warm house for the cold northern portions of the United States. There is a loft with slatted ceiling filled with straw, which absorbs the moisture from below. At each end of the loft is a door which is opened on warm days to allow the straw to dry out. Below the floor is a basement, which furnishes an ideal scratching shed for winter use. To the rear of this house is a small grove, which furnishes plenty of shade, and about 20 feet from the front of the house is a stream of water.

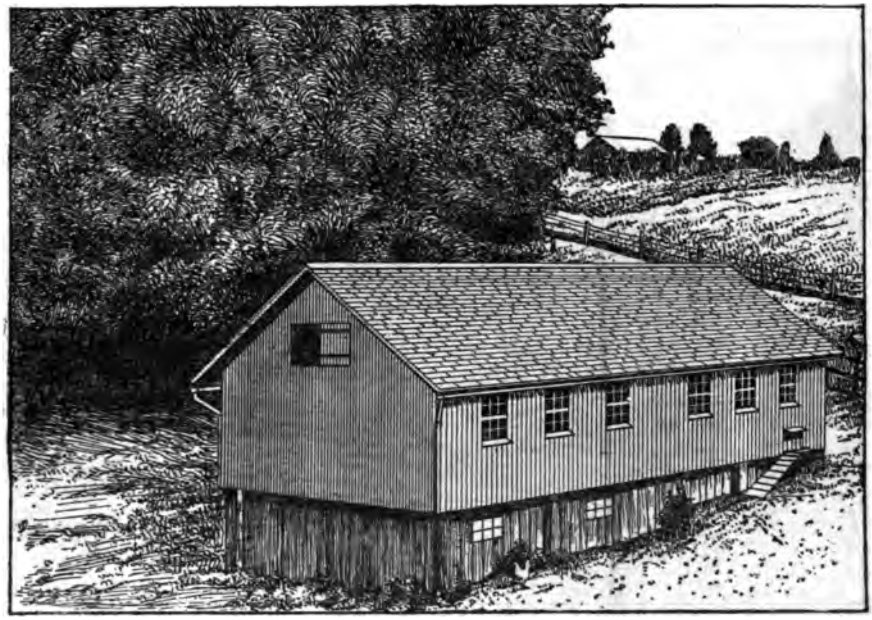
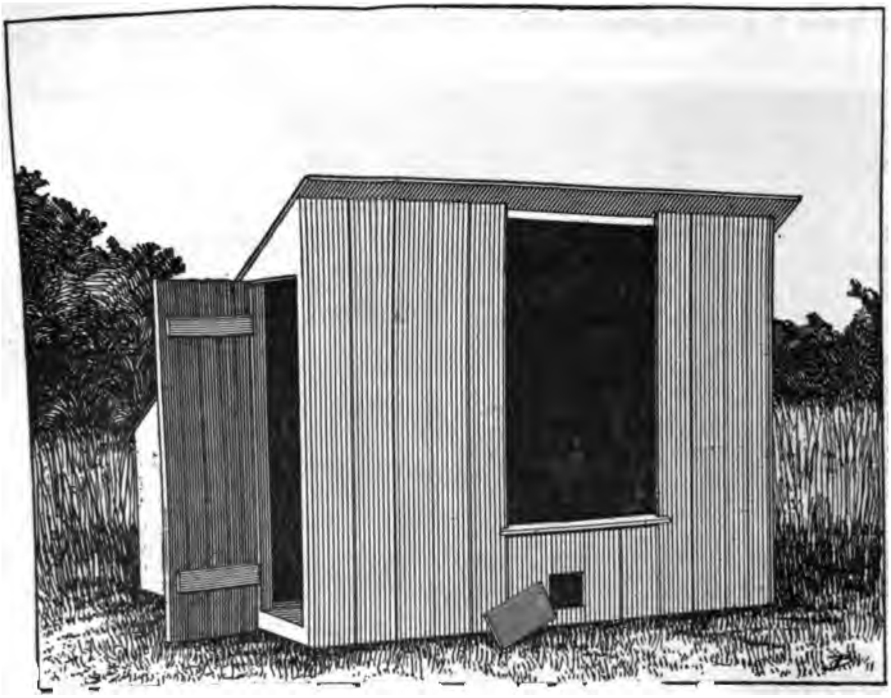


FIG. 8.—Laying house and open range.

Colony Houses.

Figure 9 shows one of the colony houses for chickens in use at the poultry farm of White & Rice, in New York State. This house is about 8 feet long and 7 feet wide, 7 feet high in front and 3½ feet in rear. The walls are built of one thickness of matched boards. The floor is of wood. A hover is placed in this house, and the chicks are placed here when first hatched. When the chicks are from 6 to 10 weeks old (depending largely on weather conditions and the development of the chicks), the heater is removed and perches are placed in the rear of the house about 16 or 18 inches above the floor.

Figure 10 illustrates a "New Hampshire" house, one of many such houses in use on Mr. Hicks's poultry farm in Massachusetts. This



[illegible]

[illegible] ut 6 feet high
[illegible] covered with
[illegible] entilation. If
[illegible] which can be
[illegible] h a house will
[illegible] or yard room,
[illegible] ly moved from
[illegible] of this shape
[illegible]

MANAGEMENT OF HENS FOR EGG PRODUCTION.

The problem of feeding is one of great importance, and should be carefully considered, for on it depends to a large extent not only the general health of the birds, but also the economy which promotes success. It is a subject, however, which should be studied with a large amount of common sense, for there are no hard and fast rules which can be laid down as applying to every case. The price of feeds and the general environment should be considered in determining the right rations.

For the largest profit a good proportion of the eggs should be secured during the winter. If two extra eggs per week can be obtained from each hen a good profit will be made, while if the product is increased by only one egg per week in winter, this one egg will pay for all the feed the hen eats. To obtain this greater production, not only should the fowls be young and of a good laying breed, but the feeder should have a full knowledge of the proper feed and its preparation.

The nutriment in the feed of laying hens serves a twofold purpose—to repair waste and furnish heat to the body and to supply the egg-making materials. As only the surplus over what is needed for the body is available for egg production, the proper feeds should be fed in sufficient quantities to induce this production.

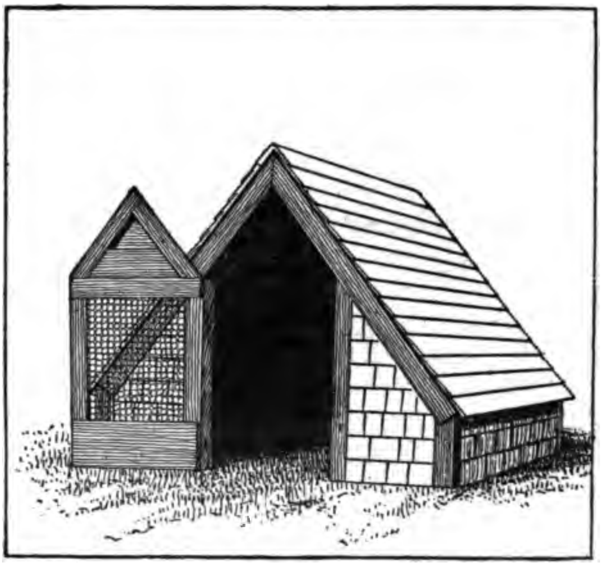


FIG. 10.—"New Hampshire" form of poultry house.

In supplying feed to fowls there are three kinds of constituents which should be present in certain fairly well fixed proportions if the desired results are to be obtained most economically. These constituents are mineral, nitrogenous, and carbonaceous, all of which are contained in corn, wheat, oats, and barley, but not in the right proportions to give the greatest egg yield. In addition some animal feed and green feed should be supplied.

In feeding poultry a valuable lesson may be learned from nature. In the spring the production of eggs on the farm is an easy matter. Fowls which are at liberty to roam find an abundance of green and animal feed on their range, which with grain furnishes a perfect ration for laying hens. In addition to this they get plenty of exercise and fresh air. So far as lies within his power, then, the feeder should aim to make the winter conditions springlike.

SYSTEMS OF FEEDING.

There are two systems in use for the feeding of fowls, in one of which all the feed is given dry and in the other of which one or more of the daily feeds consists of a moistened mash. For convenience they may be termed the "dry-feed" and the "mash" systems, although in the dry-feed system a dry mash is often fed.[a] Dry feeding is used by many where it is not convenient to make and feed a moistened mash. The greatest advantages to be derived from the dry system are the saving of labor and the lessened danger of bowel trouble resulting from sloppy or soured mashes.

Dry Feeding.

In the dry-feed system for laying hens, as successfully practiced on a New York poultry farm, the whole grains fed are as follows, in the proportions indicated:

200 pounds cracked corn.
360 pounds wheat.
130 pounds oats.

This mixture is scattered in the litter early in the morning and again at about 11.30 a. m., and this induces abundant exercise.

A hopper containing a dry mash is hung against the wall. The mash is made up of the following ingredients, in the proportions indicated (by measure):

32 parts corn meal.
30 parts meat (animal) meal.
30 parts ground alfalfa.
2 parts oyster shell.
1 part grit.
1 part charcoal.

The hopper containing this mash is opened about an hour after the noon feed of grain, or about 12.30 p. m., and the fowls have access to it for the remainder of the day.

Of all grain feeds that are usually supplied to farm poultry, corn has been and still is the most popular, which is probably due to its abundance and relative cheapness, and because it is the most relished of all the grains. Corn is heating and fattening, and when fed to closely confined fowls in large quantities fat rather than eggs is the usual result, and it should be balanced with meat, bone, linseed, gluten, and such feeds as are rich in nitrogenous matter, for corn is deficient in this constituent. When corn is fed to laying hens that have opportunity to take plenty of exercise and to secure insects and green feed, much more satisfactory results are likely to be obtained than when it is fed to the same fowls closely confined. It may be fed quite largely in the cold climates during winter, but should be fed sparingly during summer.

---

[a] By the term "mash" poultrymen mean a mixture of ground feed, which may be either moist or dry.

Wheat is generally considered the safest grain to be fed alone. It is not quite so fattening as corn, still is too fattening when fed alone. This grain should be supplemented by some meat feed or skimmed milk to increase the proportion of protein. Wheat contains more protein than corn, about the same amount of carbohydrates, but less fat, and on the whole is considered not so valuable for fattening, but better for growth. Wheat screenings, if they are of a good grade, can frequently be purchased and fed to advantage. Of course there is always the danger of introducing weed seed on the farm. " Burnt wheat " can seldom be fed advantageously, the difference in price between this and good wheat being usually too slight to warrant one in feeding it.

Oats are often fed for variety, but are not well liked unless hulled, the hulls being tough and rather indigestible. Hulled oats, on the other hand, are relished by poultry and are excellent for producing eggs. When they can be obtained at a reasonable price in comparison with other grains they may be fed quite largely.

Barley does not seem to be greatly relished by hens, but may be used to give variety to the grain ration. It has a little more protein than corn and a little less than oats.

Buckwheat is quite well liked by fowls, but is not very widely fed. It may be fed to vary the ration. Buckwheat middlings are rich in protein and make a good mixture with corn meal.

Rye is not fed largely, and does not seem to be much relished by poultry. It is supposed to cause bowel trouble when fed freely.

Mash Feeding.

It is the practice of a large percentage of the most successful poultrymen to feed a part of the daily grain ration ground. Most of them feed the ground grain moistened with either milk or water, although some feed it dry. A fowl's gizzard is capable of grinding all kinds of grain, but it is generally considered to be more economical to have a part of the grinding done by steam or water power.

The soft-feed idea, however, must not be overworked. A beginner often reasons that it is cheaper for the miller than for the fowl to grind the grain; but the powerful muscles of the gizzard are there to be used, and experience has shown that the balance of power of functions in the fowl's economy makes the vigorous exercise of the gizzard beneficial. When feeding moistened ground feed have it a comparatively dry, crumbly mash, and not a thin slop. Give what they will eat readily in 15 or 20 minutes.

Poultrymen do not agree as to the time of day when the soft feed should be fed. Some assert that it should be fed in the morning, others at noon, and still others at night. The greater proportion give the ground feed in the morning, a large number at night, and a few at noon. The number who feed at noon, however, is becoming larger. Those who give the soft feed in the morning reason that the fowls which have been on the perches during the night have largely digested the feed consumed the day before, and consequently have comparatively empty crops and digestive organs, and in order that the morning meal may be easily and quickly digested the fowls should be fed only ground and moistened feed. Other careful feeders state that if a moistened mash is fed in the morning the hen is likely to become gorged with feed early in the morning and take to the roost for the remainder of the day. It is probably more important that a part of the grain should be ground than that it should be fed at any particular time of day. In an experiment in West Virginia the egg production was practically the same whether mash was fed in the morning or at night.

The following are given as sample mashes:

100 pounds corn meal.
150 pounds ground oats.
150 pounds wheat bran.
30 pounds linseed meal.
30 pounds beef scraps.

100 pounds wheat bran.
100 pounds ground corn.
100 pounds ground oats.
100 pounds ground barley.

100 pounds corn meal.
100 pounds ground oats.
100 pounds wheat bran.

100 pounds wheat bran.
100 pounds corn meal.
75 pounds wheat middlings.
75 pounds cut clover or alfalfa.

MISCELLANEOUS FEEDS.

Animal feed.—Chickens eat a large amount of animal matter in the form of insects, worms, and other low forms of animal life when allowed to range at will. If the poultry keeper is to get the best results from his fowls in winter he must furnish a substitute for this class of feed. For this purpose green cut bone, meat scraps, and animal meal may be used. Green cut bone is usually fed by itself, while the scraps and meal may be readily mixed with the mash. Cut bone consists of green or fresh bone sliced or shaved into thin pieces by a bone cutter. Bones fresh from the butcher have more or less meat adhering, and the more of such meat the better, for the combination of bone and meat is excellent for producing eggs. Where a good supply of fresh bone can be obtained regularly it is very useful, but it can not be kept sweet for such long periods as the beef scraps and animal meal. Green cut bone should be fed carefully and in a sweet condition, otherwise bowel trouble may result. One pound a day is sufficient for 20 hens, but not over one-half pound should be fed to that number when first beginning to feed it. From one-half to three-fourths pound of animal meal or meat scraps may be fed to 12 or 15 hens. Any form of meat is likely to loosen the bowels of the hen when first fed, and the hens should be watched carefully and not fed too much. After the fowls have become accustomed to the animal meal or meat scraps it may be kept constantly before them.

Green feed.—If the best results are to be obtained with poultry they must be furnished with a plentiful supply of green feed. Where fowls have unlimited range on a farm they will secure green feed during the spring, but during the winter it must be supplied for them. The question of how to supply the best feed at the least cost is one that each poultry keeper must decide largely for himself. It will probably make but little difference what kind of green feed is supplied provided it is relished by the fowls. Cabbages, turnips, beets, potatoes, etc., are suitable for this purpose. The larger roots and the cabbages may be suspended by means of a wire or string, or they may be placed on the floor, in which case it would be well to split the turnips or beets lengthwise with a large knife. Potatoes and turnips should be fed cooked. The mangel is an excellent root for feeding raw. Cut clover soaked in boiling water fed alone or with the mash is good. Clover meal and ground alfalfa make very good feeds for this purpose. Where the fowls are yarded and not enough green feed is furnished by the yards, a small patch of clover, alfalfa, or rape may be sown. Any one of these, if frequently mowed, will furnish a great quantity of green feed in a form which is relished by the fowls. Canada field peas may also be sown for this purpose, and when fed in a tender, crisp condition are eaten readily. Rye is a good crop for late fall and early spring, for it will germinate and grow in very cold weather and will live through the winter. As a general thing, fowls should have once a day about all the green feed they will eat.

Hay.—Clover hay may be fed economically to laying hens and may be prepared as follows: Cut into as short lengths as possible (one-fourth to one-half inch) and place in a bucket. Then pour boiling water over it and allow to stand for two or three hours or over night.

When ready to feed, drain off the water and mix the hay with the mash. The hay may constitute about one-half the bulk of the feed, although the exact proportion is immaterial. Clover hay is best, but any kind is valuable. The feeder must be careful not to give too much bulky feed, for the hen, having a small crop, can not make use of as large an amount of it as the cow and other ruminants can.

Water.—Plenty of fresh water should always be accessible to the hens. If supplied irregularly they are likely to drink too much at a time. It should not be exposed to the sun's rays in summer or be allowed to freeze in winter if this can be avoided. In very frosty weather it is often worth while to give them slightly warmed water two or three times a day rather than permit them to drink water at the freezing point. A flock of 50 hens in good laying condition will require 4 to 6 quarts of water a day.

Milk.—When properly fed, milk makes an excellent feed for poultry. In feeding sour milk or buttermilk, however, the feeder must exercise care not to give too much or bowel trouble will likely result. Skimmed milk is an economical feed. In skimming, the most valuable food constituents—the nitrogenous substances—are left in the skimmed milk. Not only does this skimmed milk contain much nutritive material, but it contains it in a form which, as a rule, is easily digested. Skimmed milk may often be advantageously substituted in part for meat. Milk may be used in mixing the soft feed, or it may be given the fowls to drink in addition to water.

GRIT AND OTHER SUBSTANCES.

Grit.—Grit is essential to the health of fowls and to economy in feeding. Grit takes the place of teeth in preparing the feed for further digestion and is required for the proper preparation of feed in the gizzard. When the feed is not properly taken care of in this organ an undue strain is thrown on the fowl's system, often resulting in disease, and also allowing much of the nutriment to pass through the bird's body without being absorbed. In every pen or yard a box of grit should be kept. Recent investigators have asserted that grit is a part of the necessary feed, giving the fowls strong bones and a bright plumage.

Lime.—Ordinarily, the hen does not consume enough lime to form the shells of eggs if she is laying abundantly unless something besides the ordinary grain feeds is accessible to her. Oyster shells are very good for this purpose. A box of crushed shells may be placed before the fowls, allowing them to eat at will. Old mortar and fine gravel are also useful in supplying lime.

Charcoal.—Charcoal has a great absorptive power for gases, impurities, and acids, and thus acts as a corrective when the stomach is sour and digestion has been impaired.

METHODS OF FEEDING.

Fowls should have empty crops in the morning, and the crops should never be quite full until it is time to go to roost at night. For the first feed, grain scattered in the litter early in the morning is preferred, the sooner the better after the birds leave the roosts. This induces them to exercise, which is especially important on cold winter mornings. In the middle of the day a warm moistened mash should be given, about what they will eat within fifteen or twenty minutes, and at night, about an hour before they go to roost, a liberal feed of grain should be scattered in the litter.

Frequency of Feeding.

Some poultrymen feed their flocks twice a day, while others feed them three times a day. The best plan is to feed fowls in confinement three times a day and those having free range in summer twice a day. When there is a very long interval between feeds it is difficult to keep fowls busy which are kept in confinement. Idle fowls often contract bad habits, such as feather pulling and egg eating, besides going out of condition from lack of exercise.

In case it is not convenient to feed three times a day, the moistened mash may be fed in the morning, and at the same time the noon feed of grain may be scattered in the litter, which will keep the fowls busy a great part of the day.

For those who can not conveniently feed their fowls early in the morning a good plan is to scatter grain plentifully in the litter after the birds have gone to roost. This grain will furnish feed for the early morning.

Some poultry keepers can look after their fowls only once a day. If this is in the morning, moistened mash may be fed, followed by throwing grain in the litter to furnish feed for the remainder of the day. If it is in the evening, before dark, a moistened mash may be given, and either after the fowls go to roost or in the morning, before daylight, grain may be scattered in the litter for eating during the day.

Amount of Feed.

It is impossible to state any exact quantity of feed that should be given to each fowl per day, as the appetites of the birds vary according to the conditions under which they are kept, the season of the year, and the kind of fowl, some being much greater eaters than others. The general rule is to keep the birds slightly hungry during the day, not giving all they will eat until just before roosting time. The birds should be handled now and then when they are on the perch, and if they are either too fleshy or too poor their rations should be modified.

Importance of a Varied Ration.

In feeding grain the aim of the feeder should be to give a variety. No one kind of grain alone is best. Variety may be secured by mixing the grains or by feeding the different kinds of grain on different days. This variety is in accordance with nature. When on free range the fowls obtain a little of several different kinds of feed. Grain should not be made the sole feed, for then fat and not eggs is the usual result.

Effect of Feed on Character of Egg.

In extreme cases the flavor and the odor of the feed have been imparted to the egg. Onions have been fed in sufficient quantity to bring about this effect. Feeds of high and objectionable flavor should not be fed by those who desire to produce a first-class article. In no case should tainted feed be allowed to enter into the ration. Feed also has an influence on the color of the yolk. Corn fed exclusively will give a deep yellow or highly colored yolk, while wheat fed alone will produce a much lighter-colored yolk. A fairly high-colored yolk is usually preferred and can generally be obtained by feeding a moderate amount of corn. Plenty of green feed also enriches the color of the yolk.

THE DROPPINGS AS AN INDICATION OF HEALTH.

The condition of the droppings furnish a good indication of the hen's health. They should be of sufficient consistency to hold their shape, but should not be too solid. In color they should be dark, tapering off into grayish white. If the droppings are soft or pasty and of a yellowish or brownish color, it indicates too much carbohydrates or a lack of meat. If, on the other hand, the droppings are watery and dark with red splashes of mucus in them, it indicates too much meat. A greenish, watery diarrhea usually indicates insanitary conditions, either in the surroundings, the feed, or the water.

MOLTING.

Where a specialty is made of producing winter eggs it is important that the hens shed their feathers early, so that the new plumage will be grown before cold weather begins. Henry Van Dreser has proposed a way by which it is possible to cause a flock of fowls to pass through the molting period early and uniformly. This method consists in withholding part of the feed for about two weeks, which stops egg production and reduces the weight of the fowls, and then feeding heavily on a ration suitable for the formation of the feathers and the general building up of the system. This method was tried at the West Virginia Experiment Station with good results. The hens molted more rapidly and with more uniformity, entering winter in better condition than similar fowls fed continually during the molting period on an egg-producing ration. Whether this method is employed or not, the fowls should receive a more nitrogenous ration than the one ordinarily fed. The addition of a little linseed meal during the molting period will aid in the production of a new coat of feathers. An increase in the amount of animal feed will also be beneficial.

EXERCISE.

During the spring season fowls having free range get abundant exercise. Close confinement without exercise is not conducive to the best results, although the feed provided may be the best, for idle hens soon grow too fat to lay. It is almost impossible to give laying hens which are confined too much exercise. The fowls may be encouraged to exercise in various ways, such as feeding corn on the cob, suspending cabbage heads, beets, etc., so that the birds have to jump for them, and scattering grain in the litter. The litter should be from 4 to 8 inches deep, and may consist of straw (either cut or whole), hay, leaves, buckwheat hulls, shredded corn fodder, or any convenient material of this nature. The hens should be kept hungry enough so that they will work diligently all day for the grain scattered in this litter, which should be removed whenever it becomes damp or soiled.

AGE OF BIRDS FOR PROFITABLE EGG PRODUCTION.

There are people who have the right variety of fowls, who house and feed them properly, and yet who can not obtain eggs early in the winter because their fowls are too old. It is seldom that it pays to keep hens for laying after they are two and a half years old; not that they will not give a profit, but that younger fowls will give a greater profit. A great many poultrymen who make a specialty of winter-egg production keep nothing but pullets, disposing of the 1-year-old hens before it is time to put them in the winter quarters. Early hatched pullets, if properly grown, ought to begin laying in October or early November and continue to lay through the winter. Yearling hens seldom begin laying much before the 1st of January and older hens not until later. It is the November and December eggs that bring the high prices. The laying breeds should begin laying when about 5 months old; general-purpose breeds at 6 months, and the meat breeds at 7 or 8 months.

RAISING CHICKENS.

To be successful in raising chickens it is necessary to have healthy and vigorous breeding stock, for the lack of vigor in the newly hatched chicks is often traceable to weak parents. Only the most vigorous and the best grown birds should be put in the breeding yards. Each bird should be full of life and energy and free from any serious deformity. Yearling hens are usually better than pullets for breeders, for the reason that the hens are more mature and do not lay so many eggs during the early winter, and consequently do not reduce their vitality so much before the breeding season. Vigorous hens 2 to 4 years old can often be advantageously retained in the breeding yard. The male bird chosen should be young and active. An early hatched well-developed cockerel is usually satisfactory, or a good vigorous yearling or 2-year-old cock may be chosen. The hens used for breeding purposes should be given the best care possible; they should be provided with large runs and should not be forced for heavy egg production during the early winter.

NUMBER OF FEMALES TO ONE MALE.

Of the light, active breeds, such as the Leghorns and Minorcas, 1 male will be sufficient for a pen of 12 to 15 females under ordinary conditions. In the case of the medium-sized fowls, such as the Plymouth Rocks and Wyandottes, 1 male should be provided for every 10 or 12 females. With the heaviest breeds, like the Brahmas and Cochins, 1 male should not be mated with more than 10 females. Where 20 or 30 females are kept in one flock no better means of securing fertile eggs is known than to keep 2 male birds, allowing one of them to run with the hens one day and the other the next day, having a coop or extra pen in which to keep the one not with the hens.

HATCHING CHICKS.

There are two methods of hatching and brooding chicks—the natural, in which the chicks are hatched and brooded by hens, and the artificial, in which they are hatched in incubators and brooded in houses or in separate outdoor brooders. For the person with a small flock the natural method will be found the easier and less expensive. For the person, however, who has a hundred or more hens and intends raising large numbers of chicks, and for all who keep only the nonsitting varieties, the artificial method is the more practical. There is also the added advantage with the latter method of being able to hatch chickens at any time of the year.

Eggs for Hatching.

The eggs intended to be incubated should be kept at a rather cool temperature, 50° to 60° F. It is not advisable to keep them longer than two weeks before being incubated, and the fresher they are when set the better the chances of a good hatch and strong chicks. Only well-formed eggs with good strong shells should be set.

Number of eggs to hen.—This depends on the season, the size of the hen, and the size of the eggs. The usual number for an average-sized hen in the spring is 13. The same hen set in winter should not be given more than 11. After the middle of May she can take care of 15. It is better to give less than she can cover than to give more, for when [illegible] eggs, if not all, will be chilled [illegible] incubation.

[illegible] eggs [illegible] testing should [illegible] the removal of infertile eggs [illegible] left. If there [illegible] set on the same [illegible] should be tested about [illegible] incubator manu- [illegible] homemade tester [illegible]eboard or wooden [illegible] hand lamp, a lantern, [illegible] hole should be cut in the top [illegible] little smaller than an ordinary [illegible] The testing should be [illegible] hens are set can not [illegible] In testing, the light shining through the egg, held against the hole in the side of the box, shows the condition of the egg. An infertile egg is clear, while the fertile egg will show a spiderlike formation, a center with long, crooked threads, leading outward, and this formation will float as the egg is turned. The infertile eggs may be removed and used for cooking purposes.

Hatching Chicks with Hens.

The quarters for sitting hens should be comfortable and convenient. The hen should be free from disturbance, and be provided with a yard or run. A good nest for medium-sized hens is a box 12 by 14 inches, and 12 or 14 inches high. For large hens the nest should be 16 by 16 by 16. The narrow strip at the bottom of the front of the box should be 4 to 5 inches wide, according to the height of the box. (See fig. 11.) Barrels, half barrels, and boxes of various kinds may be used. Hay, straw, or excelsior makes a good nesting material, and this as well as the hen should be dusted with a good insect powder. When a hen is not to sit in the nest in which she has been laying, it is best that she be moved after dark, for the majority of hens will then settle down more quietly in their new quarters than if moved during the day.

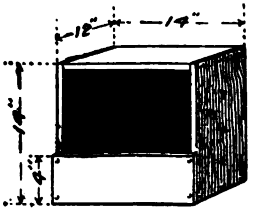


FIG. 11.—Nest for a sitting hen.

Feeding sitting hens.—Sitting hens should be well fed. Grain should be left where they can get it whenever they desire to come off the nest. Their feed should consist mostly of a variety of whole grain, such as corn, wheat, and oats. The feed a sitting hen requires is that needed for her bodily maintenance. Very little vegetable or meat should be given, for too much vegetable feed would tend to loosen the bowels, and too much meat food would tend to stimulate a desire to quit sitting and begin laying.

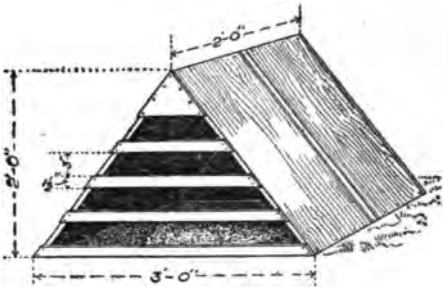


FIG. 12.—Λ-shaped coop for hen and chickens.

Taking chicks from nest.—Chicks should be removed from the nest about twenty-four hours after the first chicks are hatched. By the time the first chicks are a day old they want to get out from under the hen and move about, which is liable to make the hen restless and often causes her to leave the nest.

Number of chicks to a hen.—If the weather is cold, 10 to 12 chicks are enough for 1 hen. As the weather becomes warmer a few more may be given, but it is seldom advisable to give more than 15. The best place for the young chickens is an orchard which furnishes an abundance of shade and also admits plenty of sunlight.

Coops for hens and chickens.—The simplest coop is the common Λ-shaped coop (fig. 12). It is quickly and easily made. This coop may be made either with or without a floor. A floor is desirable, except during warm weather and where the soil drains quickly.

Another good coop is the box coop (fig. 13), which in some respects is preferable to the Λ-shaped coop, for in the latter the hen can stand upright only near the middle of the coop, while with the box coop the entire floor space is available for her and the chickens. The box coop is also more easily cleaned. If desired, a small covered run can be made for each coop. This is especially desirable if there is danger of losses from cats, hawks, etc.

Incubators and Brooders.

Incubators.—There are several good incubators on the market, any one of which, if properly handled, will be found satisfactory. More depends on the operator in most cases than on the incubator. In buying an incubator the order should be placed early without waiting until the purchaser wishes to begin operating it. Spring is a busy time for the incubator companies, and it is often impossible for them, no matter how well equipped they may be, to fill an order the same day it is received. Again, shipments are often delayed by the transportation companies. It is also advisable for every beginner to have his machine some time before he desires to fill it with eggs, in order that he may become fully acquainted with its operation. A book of instructions accompanies every incubator, which makes it unnecessary to go into details here. Probably the most common cause of failure with incubators is carelessness and neglect in attending to the machines.

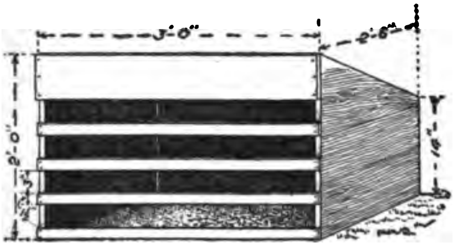


FIG. 13.—Box coop for hen and chickens.

For more details regarding incubators, see Farmers' Bulletin No. 236, entitled "Incubation and Incubators."

Brooders.—The successful growing of chicks in brooders is much more difficult than the successful hatching of eggs in the incubator, because the artificial brooding of the chicks [illegible] foreign to nature.

On a large plant [illegible] houses are an important part of the equipment [illegible] small [illegible] brooders in a small house [illegible] outdoor [illegible] purchased from the [illegible] Manufacturers usu- [illegible] while a 100-chick [illegible] hatched, it will [illegible] a few days old. [illegible] until they are about [illegible] brooder, which should [illegible] temperature should be [illegible] 70° F. is reached, [illegible] However, the tem- [illegible] should be governed largely by the [illegible] thermometer. Crowding of the chicks to the outside of the brooder, panting or breathing hard, indicates too much heat; on the other hand, crowding and huddling about the heater indicates the need of more heat. Where they spread out comfortably at night part way between the heater and brooder walls, or just inside the fringe, where a hover is used, it is a safe indication of the right amount of heat. Chicks must be kept warm while at rest, and should always have a warm place ready for them to run to when they feel chilly. They should not be allowed to huddle together outside the brooder, but should be placed inside until they learn to go there of their own accord.

The natural method of applying warmth to chicks is to their backs, and it is a generally accepted fact that in artificial brooding the heat should be supplied from overhead with a very moderate warmth from the floor. Experience has generally shown much bottom heat to be conducive to weak legs.

Pure, fresh air is as essential as heat. The most common way of supplying this air is in connection with the heating system, with a constant circulation of warm air coming in around the heater.

Cleanliness is essential, and brooders should be cleaned and aired every day, if possible, and the floor sprinkled with sand or similar material to absorb the droppings. The water fountains or dishes and the troughs used for soft feed should be kept perfectly clean.

Incubator chicks at first are generally free from lice, but during warm weather lice are apt to find their way to the brooder and it is well to keep a sharp lookout for them.

The chicks should be allowed to use the brooder until they are from 6 to 10 weeks of age (depending largely on weather conditions and the development of the chicks) when they may be removed to colony houses or to coops.

FEEDING AND CARE OF CHICKS.

There are two systems in vogue for the feeding of chicks as well as for older fowls—dry feeding and wet feeding. The former is the simpler and easier one. The beginner is advised to adopt the method he thinks he would prefer or would find more convenient and follow it until he has a good reason for modifying or changing it. Choose the one or the combination of the two most suited to your circumstances. There are various methods of dry feeding, just as there are various methods of feeding rations composed in whole or in part of moistened mashes or cakes. The grains may be fed whole or cracked, or a part ground and mixed together, making what is called a "dry mash." The feed may be kept before the chicks all the time in hoppers or troughs, or a part of it may be scattered in litter to induce them to take exercise. Beginners are usually more successful with a dry grain chick feed, for the reason that moistened mashes are thrown down carelessly in considerable quantities and soon become soiled with the droppings and begin to ferment.

The first rule for getting a good profit from poultry is to get the chicks hatched early, and the next is to keep those chicks growing so that they will reach laying maturity before the commencement of cold weather. There is no profit in keeping a chicken just alive, whether it is intended for laying stock or for the market. One reason why more care should be exercised in feeding chicks than in feeding fowls is that the former know less than the latter as to what is good for them. The healthy chick is a hungry thing and will eat what is given it, and the digestive organs being weak are less able to dispose of objectionable feed than are those of older fowls.

The first feed.—The chicks should not be fed until they are 24 hours old. Nature has provided for this by the absorption of the egg yolk into the chick's abdomen just previous to hatching. It is essential that this feed should be digested and assimilated before any other is given to them. Many people are in a hurry to start the chicks growing and hurry feed into their crops before the system is ready to take care of it. This results in bowel trouble and very often in the death of the chick. For the first meal a hard-boiled egg chopped fine, shell and all, mixed with three times its amount of stale bread crumbs, is good. In fact, boiled eggs mashed and mixed with three or four times their bulk of stale bread or cracker crumbs is excellent for pushing the young chicks along for the first week or two. However, hard-boiled eggs are concentrated feed, and if fed long and in much quantity are likely to cause bowel trouble. Stale bread soaked in whole milk or skim milk is also very good for feeding young chicks. After soaking, the milk should be squeezed out until the mass crumbles readily.

Beginning use of grain feed.—When the chicks are a few days old it is well to begin to feed a little grain. Millet seed, finely cracked corn and wheat, "pinhead" oatmeal, and broken rice may be scattered in the litter or short grass about the coop or brooder. It will pay to sift the cracked corn and wheat through sieves, so as to remove both the meal and the larger pieces. A very good mixture of cracked grains for chicks is 2 parts wheat, 2 parts "pinhead" oatmeal, 1 part corn, 1 part rice, and 1 part millet seed. Another good mixture is 10 pounds cracked wheat, 4 pounds cracked corn, 2 pounds millet seed, 2 pounds cracked hulled oats or pinhead oatmeal, and 1 pound fine beef scraps. There are also many prepared chick feeds on the market which are very good.

Frequency of feeding.—Young chicks should be fed a little at a time and often. They should be fed early in the morning and just before going to bed at night, and not less than three times in the intervening period. For the first two weeks they may be fed three meals of soft feed and two of hard, and after that age two of soft and three of hard, feeding less soft feed as they grow older. No more moistened soft feed should be given at one time than they will eat up clean. If any is left it should be removed, for nothing causes more bowel looseness and dysentery among young chicks than sour feed. The finely cracked grains may be safely used from the start, but the chicks do not as a rule grow as rapidly as when a part of the feed is ground. When the chicks are from four to six weeks old, the frequency of feeding may be decreased to four times a day.

Green feed.—Green feed must be supplied in some form. If the chicks are cooped on young grass they will help themselves, but if confined in small yards green feed should be given them. To be easily assimilated, some tender and easily broken green stuff should be furnished, such as finely cut grass from the lawns, lettuce leaves, onion tops, chopped fine, or boiled vegetables.

Animal feed.—When on free range the chicks pick up insects and worms. These are most abundant during the spring and summer, and it is at this time that the chickens thrive. When they can not get these abundantly, animal feed must be furnished in some other form. For the youngest chicks the hard-boiled eggs are sufficient, and as the chicks grow older beef scraps and green cut bone may be fed.

Milk.—Young chickens are fond of milk. It is highly nutritious and promotes growth, and may take the place of other animal feed to some extent. Skim milk is excellent; if whole milk is fed it is well to dilute it with one-third to one-half of water.

Grit.—Grit is another necessity. A dish of chick-size grit should be always before them, that they may help themselves.

Water.—Fresh, cool water should be constantly accessible, so that a drink can be taken whenever wanted. Many cases of cramps are caused by letting the chicks become thirsty and then fill up on water.

Charcoal.—Many successful poultrymen keep charcoal before the chicks, while others equally successful never use it. Considering the number of successful growers who use no charcoal, it can not be said that there is much need of keeping it always before chicks, but if they are not thrifty it is one of the simple things to supply before changing feed or beginning to give medicine.

Johnnycakes, etc.—Where only a few chicks are raised the feeding of johnnycakes is often practiced, but when so many chicks are kept that the baking of cakes becomes burdensome mash is preferable. Add a little soda to sour milk and stir in corn meal to make a stiff batter. The addition of a few infertile eggs will improve the cake. Bake until well cooked through. Make the cake thick so as to reduce the proportion of crust.

Other cakes may be made as follows: One pint of corn meal, one-half pint bran, 1 teaspoonful meat meal, 1 raw egg, 1 teaspoonful soda, add water to make stiff batter, and bake two hours.

Ten parts corn meal, 3 parts wheat middlings, 1 part meat meal, by measure; mix with water or skim milk, and bake.

Exercise.—From the very first chicks should be induced to exercise, for activity is a prime factor in promoting health and growth. Feed grain in the litter and make them scratch for it. A little fine chaff or finely cut clover makes a good litter.

Teaching the chicks to roost.—It is often advisable to teach the chicks to roost when 8 to 12 weeks of age. When they are allowed to remain on the floor it is difficult to keep them clean and to keep them from crowding. If wide roosts—3 to 4 inches—are used there is but little, if any, more danger of crooked breasts than if the chicks are allowed to remain on the floor. The chicks can generally be taught to roost by putting the perches near the floor and placing with them one or two old hens or older chicks that are in the habit of roosting. If this plan is inconvenient or does not prove effective, the chicks may be placed on the perches after dark for a few nights until they have learned to go there of their own accord.

Separating the sexes.—If convenient the sexes should be separated, for both the cockerels and the pullets will develop better. In the case of the more precocious breeds they should be separated when removed from the hen or brooder. The more slowly maturing varieties may be allowed to run together somewhat longer, but in any case the separation should be made before the cockerels begin to annoy the pullets.

BROILERS, ROASTERS, AND CAPONS.

BROILERS.

The rearing of broilers may be regarded as one of the specialties of the poultry business and does not appeal particularly to the farmer, but it can often be made a paying occupation in connection with an egg farm or as a winter employment for those whose regular occupation gives them plenty of leisure at that season. Great skill is required to bring this work to its highest perfection, and anyone contemplating the production of broilers on an extensive scale should not depend on written directions for his guidance, but should make a careful study of the market demands and should visit one of the successful broiler producers, for the practical experience of such men is the safest guide.

Broilers are young, plump chickens, weighing, when dressed, from three-quarters of a pound to 2 pounds, and are usually killed when from six to twelve weeks old. The name is derived from the fact that they are usually split down the middle and the halves broiled. The market demand to-day is for broilers of three sizes—squab broilers, small broilers, and large broilers. Squab broilers when dressed weigh from three-quarters of a pound to 1 pound each; small broilers, the size most in demand the greater part of the year, weigh from 1 to 1¼ pounds each, and large broilers from 1½ to 2 pounds each. In most American markets a yellow-skinned and yellow-legged bird is preferred, but this is not of as much importance as good quality of meat. The raising of broiler chickens until the finishing period is reached is practically the same as the raising of chickens for other purposes. The main point is to keep them growing rapidly.

To finish broilers for market.—A fat broiler is quite a rarity; the best that can be done, in general, is to have it plump, for the natural tendency of the chick is to use all nutriment for growth and development. When the birds are nearly large enough for the market they should be given all the fattening feed they will eat, and for this purpose corn in various forms should be fed freely. They will digest more feed if fed ground than if whole or cracked. A moistened mash consisting of about two-thirds corn meal and one-third bran by bulk is good. Cooked potatoes are good, and milk, with a little sugar added, will hasten fattening. Broilers may be sold alive or dressed according to the discretion of the grower. If dressed this should be done according to the demands of the market to which they are to be shipped.

ROASTERS.

For roasting, a young fowl about full grown, but still soft meated, is used, and to roast satisfactorily it must be moderately fat. Roasters are roughly classed as "small roasters" and "large roasters." The greatest demand is for small roasters weighing 4 or 5 pounds each, though the demand for large roasters weighing 8 or 9 pounds each is steadily increasing. Yellow skin and yellow legs are more generally demanded than a white skin and dark legs.

If the chickens have been properly grown and are in good healthy condition, about ten or twelve days' confinement in a pen and small yard, with fattening feed, will put them in as good condition as is desirable. They should then be dressed and packed according to market demands. The growing and marketing of roasters is an important business in some parts of the country, especially in the vicinity of large cities. Near Boston, in what is known as the "South Shore" district, the production of roasters engages the attention of many people, several of whom make it an exclusive business. A poultryman living near a good market or having good shipping facilities which bring a good market near him can often dispose of his surplus cockerels as roasters to good advantage.

CAPONS AND CAPONIZING.

A capon is a castrated male bird. After being caponized the bird becomes more quiet, is more readily fattened, the comb and wattles cease to grow, and the plumage becomes heavy and glossy. Capons neither crow nor fight and are despised by other fowls. They often show a great fondness for little chicks, and instances are not uncommon where they have been utilized in rearing broods of chickens. In many eastern markets the prices paid for dressed capons range from 20 to 30 cents a pound. The highest prices usually prevail from January to May, and the larger the birds the more they bring a pound. For this reason the larger breeds—such as the Brahma, Cochin, Langshan, Plymouth Rock, or Wyandotte—are the most suitable. If well grown, a capon will weigh from 10 to 12 pounds at 1 year of age.

Fowls hatched early in the spring can be caponized before hot weather comes, which is an advantage, although no ill results should follow the operation at any time of the year if it is properly done. Generally speaking, the bird should be from 2 to 3 months old and weigh about 2 pounds, depending largely on its development. A good set of tools is indispensable and can be purchased for from $2 to $3. As a complete set of instructions is furnished with each set it is unnecessary to go into details here. The beginner should, however, operate on several dead cockerels before attempting to operate on a live one.

After caponizing, the bird should be given plenty of soft feed and should have plenty of water to drink. The capon begins to eat almost immediately after the operation is performed, and no one would suppose that a radical change had taken place in his nature. Leave him to himself, as for the time being he is his own doctor. It is well, however, to look him over two or three days after the operation has been performed, for sometimes air gets under the skin, causing a slight swelling or "wind puff." This can be relieved by pricking through the skin at one side of the swelling with a sharp needle and gently pressing out the air with the hands. The wounds will heal within ten days from the operation. The capons should be fed nourishing but not fattening feed, the object being to keep them growing. They should be allowed to grow until about a year old, depending of course largely on their maturity, some breeds maturing much more rapidly than others.

About three weeks before marketing place the fowls in small yards and feed them three or four times a day, giving plenty of corn and other feed, or fatten them in one of the ways indicated in the section following on fattening poultry. Corn meal and ground oats, equal parts by weight, moistened with water or milk, makes a good mash for fattening capons.

In dressing capons leave the head and hackle feathers, the feathers on the wings to the second joint, the tail feathers, including those a little way up the back, and the feathers on the legs halfway up the thigh. These feathers serve to distinguish capons from other fowls in the market. Do not cut the head off, for this is also a distinguishing feature of the capon, on account of the undeveloped comb and wattles.

FATTENING POULTRY.

Four methods of fattening poultry are practiced in this country, viz: Pen fattening, crate fattening, machine cramming, and hand cramming. The first two are probably the most common to-day, while the third is gaining rapidly as its results are becoming better known, and the fourth is used only where but few birds are fattened.

PEN FATTENING.

Pen fattening is practiced by a great many people who do not have the time and inclination to use other methods. The essentials of pen fattening are quiet, darkness, except at feeding time, and plenty of soft feed given at regular intervals, usually three times a day. Birds may be kept in flocks of 15 or 20, but the sexes should be separated.

CRATE FATTENING.

In crate fattening a few fowls are confined in crates and fed from a trough. A crate 6 feet long, 18 inches high, and 18 or 20 inches wide is suitable and is large enough for a dozen birds. Sometimes each crate is divided into two or three compartments, 4 to 6 birds being placed in each compartment. [illegible] little room for the birds to move about is desirable, for the less [illegible] a bird obtains the more readily [illegible] ends of the crates should [illegible] if they are to be in a [illegible] slats should be 2 [illegible] from the troughs, [illegible] of the bottom [illegible] permit the droppings to [illegible] should be placed in a [illegible] should be admitted [illegible] three times a [illegible] time, when the [illegible]

MACHINE CRAMMING.

For the best results a machine is essential, especially for the last ten days, for otherwise the birds will not eat nearly so much as they can digest and assimilate.

Figure 14 shows a cramming machine in operation at one of the large poultry establishments in New York State. A reservoir under which is placed a small force pump operated by means of a lever worked by the foot is placed on a tripod. A tube is fixed to one end of the pump, through which the feed passes when the lever rod is lowered. This tube is of rubber or metal. If rubber, it may have a metal point. Metal tubes are more easily kept clean. The feed is placed in the reservoir, and is made into the consistency of thick cream. There are several ways of holding the bird, but the following will be found simple and effective: Fold the wings and grip the bird firmly either between the right elbow and side of the body, as shown in the illustration, or between the left elbow and the body, whichever is the more convenient. The head is grasped in the left hand, the first finger being placed in the mouth to keep it open. The tube is placed in the mouth and the bird is gently drawn on until the end of the tube reaches the crop, the neck being elongated as much as possible. The lever bar is gently lowered by the foot and the food is thus forced into the crop. One hand is kept on the crop and as soon as it is sufficiently full the foot is removed from the lever and the bird is gently removed. The operator soon learns to know when the crop is full. No stated amount that should be fed to an individual can be given, for the quantity varies with the size of the crop. Great care should be taken in preparing the feed to see that there are no lumps, for the tube is small and easily becomes blocked.

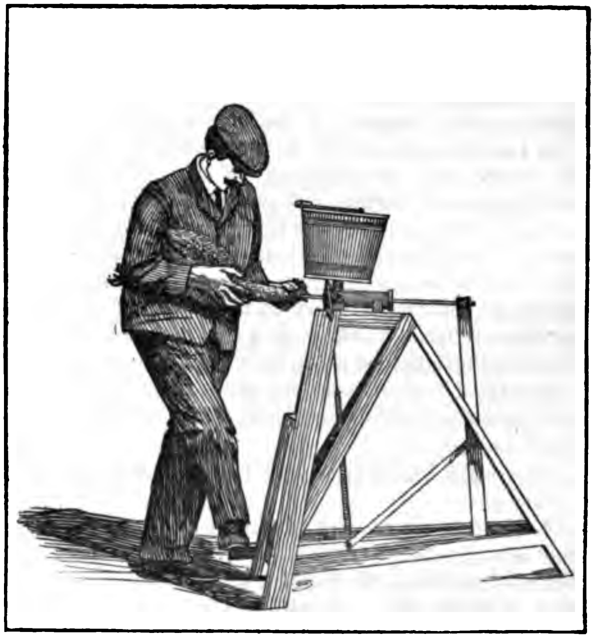


Fig 14.—Cramming machine in operation.

HAND CRAMMING.

Hand cramming is a good system where but few fowls are being fattened, but would be found rather laborious where many are fattened. The feed is made into boluses, or balls, which should be about 2 inches long and one-half inch in diameter. A large number of these are prepared before commencing to feed. The operator sits on a stool or box, firmly grips the fowl between his knees, and elongates the neck, holding the head in a similar manner to that described in using the cramming machine. He then dips a bolus in skim milk or water and forces it into the bird's mouth, pressing it down the throat with his finger. The neck above the bolus is then gripped with the thumb and first finger, which are run downward along the neck, forcing the bolus into the crop. It will probably take from 14 to 18 of these boluses to fill the crop, depending on its capacity. Some feeders practice this method in connection with crate fattening. The attendant, after feeding in the crates, feels the crop of each bird, and any not having a sufficiently filled crop are crammed in the manner described.

FEED FOR FATTENING.

Fattening birds should always receive soft feed. As they have no exercise they require a feed that can be quickly and easily digested. The following mixture is fed at the New York establishment referred to under the description of the cramming machine: 100 pounds finely ground barley, 100 pounds finely ground corn, 100 pounds finely ground oats (with hulls sifted out), to which mixture is added 10 per cent of beef scraps. Buttermilk or skim milk is used for mixing, the former being preferred. A little salt is sometimes added. The birds are fed twice a day at intervals of twelve hours, and are crammed for about three weeks. It is important that the intervals between the feedings should be as nearly equal as possible.

Another ration may be made as follows: 100 pounds ground oats, 100 pounds ground corn, 50 pounds flour, 4 pounds tallow.

MARKETING POULTRY AND POULTRY PRODUCTS.

A large part of the profit in poultry keeping often depends on the marketing of the products, and the producer should study the market demands as to how, where, and when to dispose of the products to the best advantage. An attractive appearance is of prime importance, and the [illegible] should study the details of killing, dressing, and packing [illegible] the products in the best possible manner. The requ[illegible] packing vary somewhat in different markets [illegible] special requirements [illegible] the mar[illegible]

[illegible]KEY.

[illegible] from eighteen to [illegible] to be drawn, in which [illegible] least ten hours before killing [illegible] not [illegible] water to drink for at least [illegible] kill, suspend the fowl by [illegible] the back of the throat through the mouth. As soon as this vein is cut run the point of the knife through the roof of the mouth into the brain, which causes the bird to lose all sense of feeling. Instead of piercing the brain the fowl can be paralyzed by a blow on the head.

Dry picking.—In most markets dry-picked birds are preferred. Immediately after killing, while the bird is still bleeding, the picker should remove the feathers, being careful not to tear the skin. If the picker waits until the bird is partially cold, the feathers will be removed with difficulty. As soon as picked the fowls should be hung in a cool place until thoroughly cold. If the weather is warm and fowls are to be packed in ice, they should be placed in a tank of ice water and left until all the animal heat has left the body.

Scalding.—When birds are scalded before removing the feathers they are immersed in hot water, which should be a little below the boiling point, as soon as they are through bleeding. The birds should be immersed three or four times and then picked clean, care being taken not to break the skin. The fowl should next be " plumped " by dipping it in nearly boiling hot water for eight or ten seconds and then placing it in cold water, where it should remain for fifteen or twenty minutes. Be careful not to overscald, as this will cause the outer surface of the skin to rub off. If the fowls are to be shipped dry they should be hung up until the skin becomes thoroughly dry. If they are to be packed in ice they may be left in the cold water for several hours or until they are to be packed.

Drawing.—When the poultry is to be drawn this should be done before the bird is cooled. A slit should be made from near the end of the keel bone toward the vent, large enough to admit the fingers. Then cut carefully around the vent and pull out the intestines, leaving in everything else unless the market requirements are otherwise.

Packing.—When the birds have been thoroughly cooled they are ready for packing. Packages for dressed poultry vary greatly, but they should be neat and clean and small enough to be easily handled. The inside of the box or barrel should be lined with clean, unprinted paper. Pack the birds solidly so that they will not shift in the package, but be careful not to bruise them. For delivery to retail customers pasteboard boxes of sufficient size to hold one or two birds are very satisfactory. When poultry is to be packed in ice, barrels are generally used, packing them with alternate layers of birds and ice, the latter forming the top and bottom layers.

SHIPPING LIVE POULTRY.

Poultry of all kinds can be shipped alive, and will often net the shipper as much as when dressed. Good live fowls will usually bring more than the same fowls poorly dressed. For shipping live poultry to market well constructed slatted crates are desirable, as these crates provide for ventilation. This is important, for in crowded express cars the crates are frequently piled on top of one another. Overcrowding is to be avoided, and if large coops are used they should be equipped with partitions to prevent the birds being thrown together at one end when the crate is tipped in handling. If possible place only one variety in a coop or in one division of a coop.

SORTING, PACKING, AND SHIPPING EGGS.

Eggs to be placed on the market should be carefully sorted and packed as to size, shape, and color. It is better not to put eggs having different colored shells in the same package, neither should eggs varying much in size be placed in the same package. Every egg should be perfectly clean, and if slightly soiled it may be wiped clean with a damp cloth. If badly soiled, the eggs should be discarded, for the washing required to clean them injures their appearance. The discarded eggs can be disposed of at some of the cheaper and less exacting markets. Eggs may be placed in large shipping cases or in small pasteboard boxes, according to how they are to be marketed.

TESTING EGGS.

When supplying a fancy trade with eggs, or on receiving eggs from outside sources, it is often desirable to determine their freshness. The method generally used by commission merchants for this purpose is known as "candling," and consists in holding the egg between the eye and a light so as to note the contents. This should be done in a darkened room, using one of the egg testers on the market or the simple homemade tester described on page 28 under the heading "Testing the eggs." The air space in a perfectly fresh egg is very small, and as the egg loses part of its contents by evaporation this air space increases in size with the age of the egg. Fresh eggs should appear clear and bright, showing no dark spots. Those accustomed to "candling" soon learn to detect stale eggs with a good degree of accuracy and rapidity.

Another method employed by some who have not a great number to test is to put the eggs in a basin of water. If good they will lie on their sides; if bad they will stand on the small ends. The older the egg the more upright it stands, and if very old it will be suspended in the water or even float on the surface.

METHODS OF SELLING.

There are three general ways in which poultry products may be marketed: First, selling direct to the consumer; second, selling direct to the retailer, and, third, selling to commission merchants for sale on the open market.

Selling direct to the consumer.—This is generally considered the most profitable method of disposing of high-grade goods, for the charges of middlemen are eliminated. The producer is often so situated that he can build up a retail trade among the families of a neighboring city or village, delivering his goods direct to the customer once or twice a week, or oftener if desirable. In this way he can usually secure a substantial increase over prices paid in the open market. This is especially true in the case of strictly fresh eggs. It is also often possible to secure customers in a city that is within reasonable shipping distance, expressing to them a stated amount of eggs and dressed poultry at regular intervals (once or twice a week). Hotels, restaurants, and clubs are good customers, which can be supplied in this way by contract.

Selling direct to the retailer.—There are often many grocery and provision dealers who cater to a select trade to whom the producer can sell regular supplies of fresh eggs and poultry.

Selling to commission merchants.—This is the simplest method of disposing of the produce, as it does away with the expense and trouble involved in a private trade, but the returns are usually not so great, except when dealing with certain commission houses that have built up a fine trade along certain lines.

Which of the above methods will pay him best is a question for the producer to decide for himself. It is largely a question of market conditions, personal circumstances, and the kind of business done, whether large or small.

PRESERVING EGGS.

Many people wish to preserve eggs for home consumption, and so a few methods are given which have proved sufficiently satisfactory to warrant the preservation of eggs for home use.

Eggs to be stored should be: First, from hens that have no males running with them, because an infertile egg keeps longer, even without the use of a preservative, than a fertile egg; second, perfectly fresh, for not only will they keep much better, but if an egg which has begun to decay is placed in the same vessel with fresh ones it is likely to affect all the surrounding eggs, and, third, perfectly clean, for filth of any kind adhering to the shell will taint the preserving medium and thus taint the other eggs.

In placing eggs in the preservative be careful not to crack the shells. Keep them in a moderately cool room where the temperature may be kept fairly constant. A dry, clean cellar is a suitable place.

Water-glass.—Of the many methods which have been tried for preserving eggs on a small scale none has proved more successful than the use of water-glass (sodium silicate). This is a very cheap product that can usually be procured at not to exceed 50 cents a gallon, and 1 gallon will make enough solution to preserve 50 dozen eggs, so that the cost of material would not exceed 1 cent a dozen. Pure water that has been boiled and then cooled should be used. To each 15 to 20 quarts of water 1 quart of water-glass should be added. The solution should be prepared, placed in the jar or other suitable vessel, and the fresh eggs added from time to time until the jar is filled, but be sure that there is 2 inches of the solution covering the eggs. The eggs should not be washed before packing, for washing injures the keeping quality, probably by dissolving the mucilaginous coating.

Limewater.—A good limewater preservative may be made as follows: Thirty gallons of water, 10 pounds of salt, one-half bushel of finely slaked lime. After mixing thoroughly allow the solution to stand two or three days and then remove the clear liquid by dipping or by means of a siphon. Place the liquid in a tub or other suitable receptacle and place the eggs therein, or the eggs may be placed in the vessel first and the limewater poured over them. Have about 2 inches above the eggs. Limed eggs can be discerned by the roughness of the shell.

Before boiling eggs which have been preserved in the foregoing ways, the shell should be punctured with a needle, otherwise it is apt to crack as soon as placed in hot water, owing to the pores being closed.

Salt and bran.—Eggs can be preserved for several months in dry salt. Have at least 2 inches above the upper layer of eggs. Packing in bran has also been found satisfactory in many cases.

Cold storage.—This is undoubtedly the best and most practical method for preserving eggs in large quantities in a commercial way. As the processes by which a low temperature can be maintained for an indefinite period have become more and more improved the greater has been the number of eggs so stored, until the cold-storage business has reached such proportions that it has a considerable influence on the price of eggs, tending to lower it in winter and raise it in summer. Cold storage, however, is not usually available or practicable for preserving eggs in a small way for home use.

DISEASES, BAD HABITS, AND INSECT PESTS.

It is not the purpose of this article to go into the details of the various diseases of poultry, but simply to consider briefly some of the common ailments and to give some of the simple remedies. Prevention is better than cure, so it will be well to consider some of the more frequent causes of diseases in general. Filth, dampness, improper ventilation, improper feeding, and the introduction of infected birds into the yard may be mentioned as some of the most common causes.

IMPORTANCE OF CLEANLINESS.

Everything about a poultry house should be kept reasonably clean. As a rule droppings should be removed daily, for the accumulation of excrement harbors parasites, contaminates the air, and breeds contagion. After the dropping boards have been cleaned, they should be sprinkled with road dust, coal ashes, land plaster, or air-slaked lime to absorb the liquid excrement. Nests in which straw or other similar material is used should be cleaned out and new straw put in about once every three or four weeks, or oftener if it becomes damp or dirty.

The quarters should be thoroughly whitewashed at least once a year, late in summer or early in the fall. The whitewash can be made by slaking lime in boiling water and then thinning to the proper consistency for applying. The addition of 4 ounces of carbolic acid to each gallon of whitewash will increase its disinfecting power. The runs should be plowed occasionally in order to bury the accumulated droppings and also to turn up fresh soil.

DISEASES.

When a disease has become firmly established in a flock or a single bird is badly affected, the free use of the hatchet is usually the most practical method, as it does not pay to spend two dollars' worth of time in curing a one-dollar bird. Slight cases, however, can often be cured with but little trouble. In nearly every instance it is better to remove the well fowls and put them by themselves, and in the case of infectious disease the premises should be thoroughly disinfected.

Apoplexy.—This is a disease of the brain caused by the rupture of one of the blood vessels. The bird is attacked suddenly and falls down, apparently dead or nearly so. The usual cause is too high feeding, but it may also be due to some other provocation, such as sudden fright, violent exertion, or straining in laying eggs. Fowls are sometimes found dead on the nest or under the perches. There is usually no previous warning, and so in most cases treatment is impossible, as the bird usually dies almost immediately. When, however, the sufferer is still alive pierce a vein on the underside of the wing and let it bleed freely. This will reduce the pressure on the brain and often result in a cure. The bird should then be kept on a limited diet for some time in order to reduce the surplus fat. As preventive measures, regulate the diet and give plenty of exercise.

Vertigo.—This is also a disease of the brain and may be regarded as a minor kind of apoplexy. The bird shows giddiness, throwing its head upward, backward, or to one side. The gait is uncertain and staggering, the sufferer often running around in a circle. Sometimes the bird falls to the ground, fluttering and making convulsive movements with the legs. The bird can often be revived by holding its head under a stream of cold water. After this keep the bird in a cool and shady place for some time and regulate the diet.

Bronchitis.—Bronchitis is a cold accompanied by a rattle in the throat or by a cough, and may be caused by exposure to dampness or cold temperature or by drafts of air. In the majority of cases the removal of the cause and good care will result in a cure. Inhalation of steam or vapor from boiling water has been found beneficial. Giving a teaspoonful of equal parts of cider vinegar and water has proven successful in some cases.

Catarrh.—Catarrh is a form of cold that is quite common among fowls, and may be caused by dampness, drafts of air, or exposure to cold. It is indicated by a watery discharge at the nostrils, which later becomes more viscid. Remove the cause, keep the birds fairly warm, and give them plenty of easily digested feed. The injection of kerosene into the nostrils is also beneficial. This may be done with a small syringe, a medicine dropper, or a small oil can. If catarrh has become confirmed, the nostrils and throat should be cleansed with hydrogen peroxide and equal parts of water several times daily, and the nostrils greased with vaseline.

Diphtheria.—The marked symptom is the appearance of a diseased growth in the throat and inside of the mouth, resembling raised patches of whitish or pale-yellowish skin, which may invade the entire throat and mouth, often also appearing like ulcers or sores on the face, comb, and about the eyes. Make a swab of cotton tied on the end of a stick and swab out the mouth with hydrogen peroxide. Remove any of the growths that come away easily. This disease is very contagious, and any birds suffering from it should be removed from the flock and the premises disinfected.

Roup, or contagious catarrh.—The first symptoms of this disease are similar to those of simple catarrh, but as the disease advances there is often swelling of the sides of the head and the nostrils become closed with thick mucus, causing the bird to breathe through the mouth. If the swellings contain pus, they should be opened with a sharp instrument, the contents removed, and the wound treated with a mild antiseptic, such as a 2 per cent solution of carbolic acid. The application of kerosene mixed with an equal part of olive oil has given good results in many cases. When a fowl has a bad case of roup, it is usually better to kill it, unless especially valuable.

Pip.—This is a condition of the tongue caused by some such ailment as a cold, which compels the bird to breathe through the mouth. The continual passing of air over the tongue causes it to become dry, hard, and scaly, especially about the tip. The best remedy is to remove the cause, also wet the tongue two or three times a day with a mixture of glycerin and water, equal parts.

Bumble foot.—This is caused by bruises on the bottom of the foot, and is often due to the fowls having to fly from rather high perches and alighting on hard and uneven surfaces. Remove the cause by lowering the perches. If the foot is swollen and the swelling is filled with pus, it should be lanced and the pus permitted to escape. The wound should then be washed out with a 2 per cent carbolic-acid solution, greased with vaseline, and wrapped with a piece of cloth.

Cholera.—This is a contagious disease caused by bacteria, and is usually brought in by the introduction of infected birds or by water or feed contaminated by the excrement of sick birds. It is also possible for fowls to be infected through wounds or even by the inhalation of germs in the form of dust. The symptoms include great thirst and the voiding of feces of which the part normally white is yellow. This is not a sure indication of the disease, for the same thing may occur as the result of other disorders. Diarrhea is generally a prominent symptom, the droppings being thin and voided frequently, and in the later stages the yellow portion may change to green; the fowl becomes depressed, the feathers become ruffled, the comb becomes pale or very dark, and the bird has a poor appetite. Sometimes the disease runs rapidly through a flock, destroying the greater part of the birds in a week, or it may assume a more chronic form, extend slowly, and remain on the premises for several weeks or months. Fowls affected with this disease usually die within thirty-six hours. Most so-called cases of cholera are simply diarrhea.

In most cases medical treatment for cholera has proved unsatisfactory. The best method of combating this disease is to carry out strict sanitary precautions as regards cleanliness and disinfection, and to totally destroy the carcasses of dead birds. Droppings should be burned or thoroughly disinfected by mixing with a 10 per cent solution of carbolic acid. Disinfect the building by spraying thoroughly with a 5 per cent solution of carbolic acid, and then whitewash.

Crop bound.—The crop sometimes becomes overloaded with feed, and its thin muscular walls become distended and partially paralyzed, so that the organ can not be emptied, or the opening into the lower esophagus may become clogged with a feather, a straw, or some other substance which the bird has swallowed. The crop is greatly distended and the mass of feed is rather hard and firm. In both cases the symptoms are the same and treatment should be conducted on the same principles. For treatment pour one-fourth to one-half ounce of melted lard or sweet oil down the throat and manipulate the contents of the crop with the hand in such a way as to tend to break up the mass. Unless the passage is closed the contents of the crop will usually pass away within a few hours. For a few days feed should be limited in quantity. If the foregoing method is ineffectual and an operation becomes necessary, clip away the feathers from a portion of the crop and with a very sharp knife, lancet, or razor make an incision about 1½ inches long through the skin and the wall of the crop. Then carefully remove the contents of the crop with the finger, the handle of a spoon, or some other convenient object, and wash out the crop with warm water. Pass the finger, well oiled, into the esophagus to see there is no obstruction. Sew up the wall of the crop first and then the outer skin, using white silk or linen thread, being careful not to sew the two membranes together, and in a few days the wound will be healed. Feed sparingly on whole grains until the wound heals, and do not give any water for twenty-four hours.

Diarrhea.—This is caused by some irritation of the digestive system, and may be due to the quantity of the feed, the quality of the feed or drinking water, or to climatic conditions to which the fowl has been exposed. There is a general depression, roughness of plumage, and a loss of appetite, and usually frequent expulsion of soft, whitish, yellowish, or greenish excrement, the droppings becoming more liquid until severe diarrhea is present. When the affection is at all serious, the excrement may become mixed with mucus or blood. It is important that the cause be sought out and removed. See that the birds have comfortable quarters and that they are not exposed to drafts, cold or dampness. If taken early, diarrhea can often be checked by reducing the amount of green and animal feed and feeding largely on dry feed, eliminating the moist mash. Give a tablespoonful of sweet (olive) oil as a laxative to carry off any irritating matters that may be in the intestine. In severe cases give 5 to 10 drops of laudanum to each bird.

Gapes.—Gapes is caused by the presence of small worms, which are attached to the lining of the trachea or windpipe, where they cause much irritation and often death to young chickens. Gapes usually occur when the chicks are from 2 to 6 weeks old. Separate the well from the sick birds and clean the coops, pens, and feed and water dishes by disinfecting with a 5 per cent solution of carbolic acid. Sometimes the worms can be removed from the trachea by inserting a feather moistened with turpentine or kerosene. The oil will cause the dislodgment of the worms, and some will be drawn out with the feather while others will be expelled by coughing or sneezing. Place the chicks on a piece of paper, so that the worms may be caught and burned.

Freezing (frostbite).—If the comb or wattles of fowls become frozen, and it is discovered before they thaw out, apply snow or cold water to remove the frost, for this gradual thawing will often save them. Then apply vaseline to the affected parts twice a day.

Scaly legs.—This is caused by a mite which burrows under the scales of the feet and shanks, and is considered to be infectious, but does not spread rapidly. It is noticed most frequently in old fowls. The scales can be removed by soaking the feet and shanks in warm, soapy water and by rubbing or brushing them off with a toothbrush or nailbrush. After the scales have been removed apply sulphur ointment or equal parts of melted lard and kerosene. The frequent application of kerosene has also been found effectual without the previous soaking in water.

Chicken pox, or sore head.—This is a contagious disease caused by a fungus, and occurs in chickens, turkeys, pigeons, and sometimes in geese. It is quite prevalent and very destructive among young chicks in the Southern States. The disease appears as an eruption of yellow nodules about the beak, nostrils, eyes, and other parts of the head. These nodules reach their full development in five to ten days, when they emit a watery discharge, which later changes to a thick yellowish matter. As the disease progresses the birds grow thin and weak, and death results. In cases of spontaneous recovery, the nodules dry up and form crust, which later crumble away. The parasite causing it penetrates the skin of a healthy individual either through an abrasion, through punctures caused by bites of lice, etc., or less frequently through the normal skin. The disease is most prevalent during warm, damp weather, and consequently is most fatal to late-hatched chicks.

The following preventive measures should be employed: Keep affected birds from the premises; keep the houses clean and dry, and hatch the chicks early. Sick birds may be treated by applying carbolic ointment, or glycerin containing 2 per cent carbolic acid, to the affected parts twice a day. The sores may also be bathed with soap and water to loosen the crusts and subsequently sponged with a solution of copper sulphate (one-half ounce to 1 quart of water). When other treatments are unavailing, tincture of iodine may be sparingly used.

Egg-bound.—Irritation of the oviduct, causing the membrane to become dry and deficient in its normal lubrication, an abnormally large egg, or a too fat condition of the hen may cause difficulty in expelling an egg from the body and produce the condition known as egg-bound. If the egg remains in the oviduct for a considerable length of time inflammation is produced, which finally develops into decomposition of the tissues and results in death. Fowls when egg-bound are restless, going frequently on the nest, showing a desire to lay and, in general, giving evidence of being in distress. Later they become dull and listless, remaining in this condition until death if not relieved. The egg can usually be felt in the posterior portion of the abdomen. If the trouble is early discovered, inject a small quantity of oil into the vent, and gently try to work the egg out. If this treatment is unsuccessful, hold the lower part of the body in warm water for half an hour, or until the parts are relaxed; then treat as above. It may be necessary to break the egg, allow the contents to escape, and remove the shell in pieces. After removal of the egg give soft cooling feed.

Occasionally difficulty in laying an egg causes prolapsus or eversion of the oviduct. When this occurs the oviduct is partially turned inside out and protrudes from the vent. If the egg causing the trouble has not been expelled, remove it, wash the exposed portion of the oviduct with warm water, apply carbolated vaseline or lard, and return to its normal position by gentle pressure. In addition it is well to give the fowl 3 to 5 drops of fluid extract of ergot.

Intestinal worms.—Worms are frequently present in the intestines and ceca of chickens, particularly young chicks, often causing considerable loss. Practically the only way to determine that worms are present is to examine the ceca and intestines of dead chicks.

The worms are small and hairlike. Occasionally flat tape worms are found, but these are not very common. Chicks infested with worms go off feed and become thin and sickly looking.

In combating worms care should be taken to keep clean the soil over which the chicks run, and to move the runs each year or two if possible. Cleanliness in the house must also be observed. In treating affected birds, powdered areca nut (20 to 40 grains per fowl), administered either in mash or mixed with butter and made into pills, is an effective remedy. Powdered male fern (30 grains to 1 dram), or oil of turpentine (1 to 3 teaspoonfuls), alone or diluted with an equal bulk of olive oil, is also very good. It is well to follow any of these remedies with a dose of castor oil (1 to 3 teaspoonfuls).

Limber neck.—This disease, as its name indicates, is characterized by the limp condition of the neck, the fowl practically losing all control of the neck muscles, so that the head rests on the ground. This condition occurs in warm weather, and is caused by the fowls eating decomposed flesh in which a ptomaine has developed. This poison causes partial paralysis of the neck muscles and often results in the death of the birds. Maggots eaten by fowls do not cause the disease, except as they may contain the poison which they have obtained from the decaying flesh.

The best and most effective treatment is, of course, never to leave any dead fowls or other dead animals around, but to bury or burn all carcasses. Treatment of sick birds is not usually very successful, but a teaspoonful of castor oil is sometimes effective.

BAD HABITS.

Egg eating.—This habit sometimes becomes a serious vice, fowls becoming very fond of eggs when they have learned to eat them, and it often spreads from fowl to fowl. It usually begins through accident by eggs being broken or frozen. Be careful to see that this does not happen. See that the nests are properly supplied with straw or other nesting material and have them darkened, so that if an egg is accidentally broken the fowls will not be likely to discover it. Supply plenty of lime in the form of oyster shells, bone, or similar substances to insure a firm shell. As soon as it is discovered that a fowl has formed the habit the fowl should be removed, in order to prevent the spread of the vice. Once formed, it is difficult to eradicate, and the safest remedy is the death penalty.

Feather eating.—Fowls sometimes pluck feathers from themselves and from each other, which is often caused by too close confinement, by the presence of insect pests, or by improper feeding. When some of the fowls of a flock have formed the habit slightly, a wide range with a change of diet, including a plentiful supply of animal feed, and freedom from insect pests, will usually correct the evil. Above all see that the fowls have plenty of inducement to exercise. If the habit becomes well formed it is very troublesome and may necessitate the killing of some of the fowls in order to stop it.

INSECT PESTS.

Two classes of external parasites, popularly known as lice and mites, will be considered here. There are several varieties of lice which attack poultry. They subsist mainly on the feathers and perhaps on the epidermic scales. They are found largely on the head and neck, under the wings and about the vent, and when present in large numbers they cause the fowls much discomfort. Persian insect powder (pyrethrum), powdered sulphur, and some of the various preparations on the market, such as the louse powders, are good in combating these pests. The hens can be dusted with one of these powders after they have gone to roost. Have the powder in a box with a perforated cover, grasp the fowl by the legs, and shake the powder well among the feathers. Dust at least three times at intervals of about a week in order to catch the lice which hatch out after the first dusting.

The mites subsist on the blood of the fowls and are not usually found on the bodies of the bird except when at roost or on the nest. During the day they inhabit cracks and crevices of the walls, roosts, and nests. Sitting hens are often so annoyed that they are compelled to leave the nests in order to relieve themselves of these parasites. The free use of kerosene about the nests and perches is useful in fighting mites. The walls of the house may be sprayed with kerosene, the operation being repeated every three or four days for two weeks. Insect powders are of little avail.

The following method has proved excellent in ridding houses of mites and lice when the weather conditions are such as to permit the birds being kept outside the house for five or six hours. Close all the doors and windows and see that there are no cracks or any other openings to admit air. Get an iron vessel and set it on gravel or sand near the center of the house; place in the vessel a handful of shavings or straw saturated with kerosene, and on these sprinkle sulphur at the rate of about 1 pound to every 90 or 100 square feet of floor space. Instead of using the shavings and kerosene the sulphur can be saturated with wood alcohol. When everything else is in readiness light the material and hastily leave the house. In case any anxiety is felt about fire, a glance through a window will show whether everything is all right. There is very little danger of fire when proper precautions have been taken to have plenty of soil beneath the vessel. Allow the house to remain closed for three or four hours, at the end of which time one can safely conclude that there are no living beings inside. Now throw all the doors and windows wide open so as to drive out the sulphur fumes thoroughly, and then the fowls may be allowed to enter. Let them in one by one, and as each enters catch it and dust it well with insect powder, which will destroy the lice on the birds. Tobacco dust is also good to use instead of insect powder. The birds and house have now been freed from vermin for the present, but the eggs of the insects have not been destroyed, and in a week another swarm will be hatched out. Therefore it will be necessary to repeat the operation once or twice before the pests are exterminated. After this care should be used to see that no strange fowl is admitted to the house or yard without having been thoroughly rid of lice, for one lousy hen will contaminate all the rest.

O

Issu

U. S. DEPARTMENT OF AGRICULTU

FARMERS' BULLETIN No. 288.

THE NONSACCHARINE SORG

BY

C. W. WARBURTON,

Assistant Agriculturist, Farm Management Investigati
Bureau of Plant Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

CONTENTS.

Page.

Classification of sorghums 7

Introduction into the United States 7

The groups of nonsaccharine sorghums 8

Characteristics of the different varieties 9

Importance of the crop:

- Sections where sorghums are valuable 11
- Acreage grown 11

Soils adapted to the crop 12

Drought resistance 12

Alkali resistance 13

Effect of sorghums on the land 13

Preparation of the soil 14

Planting:

- Date of planting 15
- Quantity of seed necessary 15
- Methods of planting:
  - Listing 16
  - Surface planting 16
  - Drilling and broadcasting 16

Cultivation 16

Harvesting 17

Thrashing 19

Yields 20

Utilization of the crop:

- Fodder 21
- Hay 22
- Pasture 22
  - Danger from poisoning 23
- Silage and soiling 23
- Grain:
  - Feed for cattle 23
  - Feed for hogs 24
  - Feed for sheep 24
  - Feed for horses 24
  - Feed for poultry 25
- The grain as food for man 25

Feeding value and chemical analyses 25

Market for the seed 26

Diseases and injurious insects 26

Improvement of the crop 27

Summary 28

B. P. I.—265.

THE NONSACCHARINE SORGHUMS.

CLASSIFICATION OF SORGHUMS.

All the varieties of sorghum now in cultivation are supposed to have originated from a single species native to tropical Africa. The differences which mark them so far as botanical characters are concerned are comparatively slight and unimportant. The forms cultivated in the United States may be divided into three classes: (1) Broom corns, (2) saccharine sorghums, and (3) nonsaccharine sorghums.

The broom corns are distinguished by their dry, pithy stalks and by their long, loose, open seed heads, which are used in the making of brooms and brushes. The saccharine varieties are marked by their tall, leafy stems, which are full of sweet juice. The seed heads of the different varieties are quite variable in shape and color. The nonsaccharine varieties are usually more stocky than the saccharine sorts and contain less sap, though some of them are quite juicy and sweet. The saccharine sorghums are grown for forage and the production of sirup; the nonsaccharine sorts for forage and grain. This bulletin deals only with the latter class.[a]

INTRODUCTION INTO THE UNITED STATES.

Although chicken corn and some of the other less important nonsaccharine sorghums were brought into this country in colonial times, none of the varieties became prominent as farm crops until about twenty years ago. The settlement of the semiarid section of the Great Plains in Kansas, followed by the development of similar portions of Oklahoma and Texas, caused a demand for a drought-resistant grain crop to take the place of corn, and demonstrated the usefulness of Kafir corn and milo. These sorghums had been introduced some years previous, but were considered of little value up to this time. Some of the varieties of the dura group had been brought into the Southern States at a much earlier date, but they had only been grown in a very limited way. Kafir corn quickly found favor in Kansas, and the area devoted to it increased steadily up to 1900. Since that time its acreage has remained quite constant, and the crop is one of the most important ones in the State. It is grown largely in Oklahoma also, while in Texas Kafir corn and milo are the most popular crops in the Panhandle and adjacent sections.

---

[a] Farmers' Bulletins No. 174, "Broom Corn," and No. 246, "Saccharine Sorghums for Forage," discuss the first and second classes of the sorghums.

THE GROUPS OF NONSACCHARINE SORGHUMS.

The nonsaccharine varieties of sorghum principally grown in the United States are divided into two groups: (1) The Kafir corn group and (2) the dura group. The Kafir corn group takes its name from the tribe of Africans from whom it was obtained when introduced into this country. It includes Red Kafir corn, White-Hulled White Kafir corn, and Black-Hulled White Kafir corn, and is characterized by its long, erect, slender heads, compact and full of obovate seeds (egg-shaped with the large end outermost), either white or red in color. White-Hulled White Kafir corn is of no importance at the present time, having been replaced by Red Kafir corn and Black-Hulled White Kafir corn. White milo, African millet, and Indian millet are old names for the white varieties of Kafir corn. Black-Hulled White Kafir corn is now commonly known as White Kafir corn and as Black-Hulled Kafir corn, and the term "White Kafir corn" as used in this bulletin refers to this variety. A head of White Kafir corn is shown in figure 1.

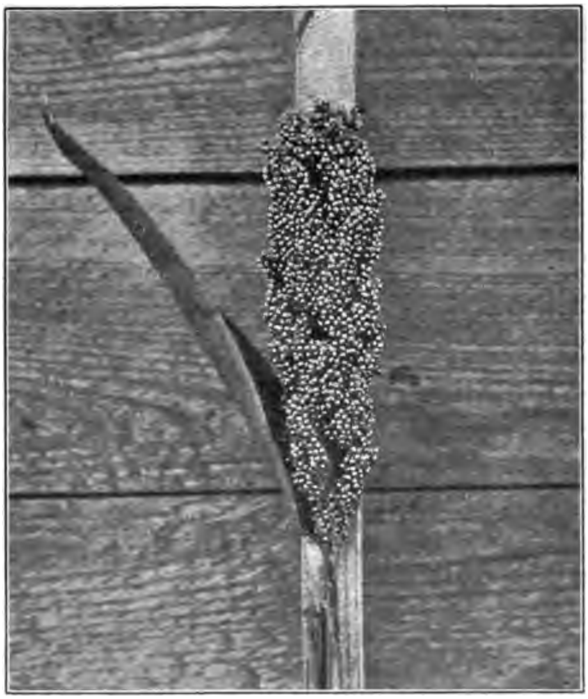


FIG. 1.- Head of White Kafir corn.

The dura group of sorghums includes brown dura, Jerusalem corn, and yellow milo. These varieties are characterized by their thick, compact, ovate (egg-shaped) heads, which frequently turn down, or "gooseneck," and their large flattened seeds, white in Jerusalem corn, reddish brown in brown dura, and reddish yellow in yellow milo.

In California this group is generally known as Egyptian corn. Various names have been applied to the different varieties by seedsmen and farmers in other sections. Among those by which brown dura is known may be mentioned dhoura (also spelled durra, durah, doura, and in various other ways), Dhoura corn, Rural Branching dhoura, and Rural Branching sorghum. Yellow milo is known as Millo maize or Milo maize, Yellow Branching sorghum, Dwarf milo, and Red milo maize. Jerusalem corn has also been known as Egyptian Rice corn. A head of yellow milo is shown in figure 2.

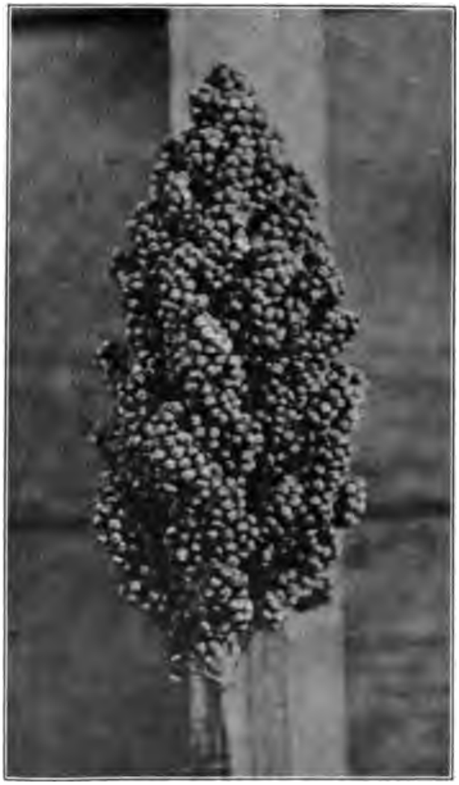


FIG. 2.—Head of yellow milo.

CHARACTERISTICS OF THE DIFFERENT VARIETIES.

The several varieties of Kafir corn are short, stocky, broad-leaved sorghums, producing a considerable quantity of excellent forage in addition to a good grain yield. They are decidedly drought resistant, in that they are able practically to suspend growth during very dry periods. Later, if rain falls, these varieties will resume growth and will produce a crop of seed. Occasionally, however, the rains are so long delayed that they fail to mature seed before frost. The dura group, especially yellow milo, continues growth during a drought and produces some seed under almost any conditions. For this reason yellow milo is better adapted than Kafir corn to sections of very low rainfall. With good cultivation large crops of both Kafir corn and milo may be produced with 10 to 12 inches of rain during the growing season. A field of yellow milo grown under favorable conditions is shown in figure 3.

The different varieties of Kafir corn, especially when selected seed is used, are very uniform in growth, and as the heads are always erect the crop is easy to harvest by any of the.common methods. The dura group is much more variable in height, and as the heads are frequently recurved, or goosenecked, the crop is more difficult to harvest than Kafir corn. This may be largely obviated, however, by thick planting.

The stalks and leaves of Kafir corn remain green until the head is fully matured, while in the varieties of the dura group they are nearly dead when the seed ripens. For this reason Kafir corn is usually considered a better forage plant than any of the other sorts. The stalks of Kafir corn frequently contain considerable sweet sap, and milo is occasionally quite juicy, but Jerusalem corn and brown dura are generally dry and pithy. As the sweet juice adds materially to the palatability of the fodder this is an additional reason for using Kafir corn as a forage crop in preference to any of the varieties of the dura group.

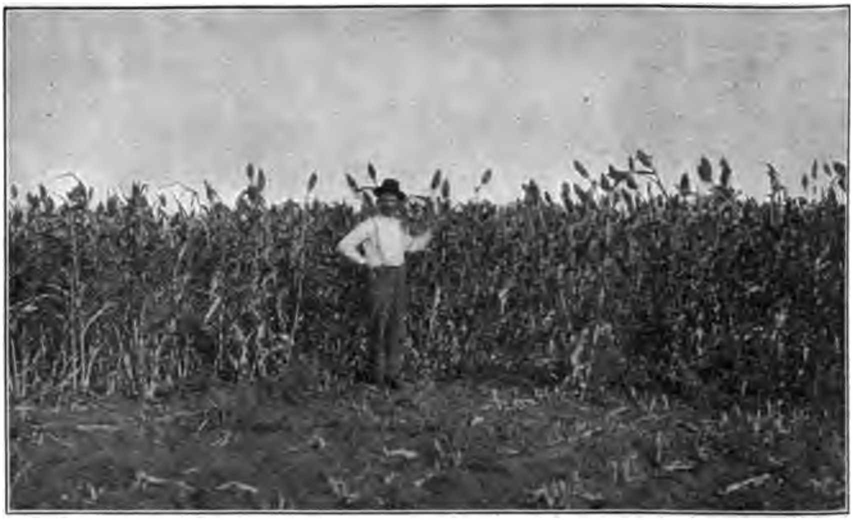


FIG. 3.—Field of yellow milo.

Kafir corn requires from 110 to 135 days to mature seed; milo, Jerusalem corn, and dura will ripen in 90 to 110 days. An objection frequently urged against Jerusalem corn and dura is that the seed shatters badly as soon as it matures; milo and Kafir corn give little trouble in this respect. All of the varieties are much relished by birds, and considerable seed is destroyed by them. It is not advisable to plant small patches of any of these sorghums where sparrows are numerous, but the damage where large fields are grown is comparatively slight.

IMPORTANCE OF THE CROP.

SECTIONS WHERE SORGHUMS ARE VALUABLE.

The nonsaccharine sorghums are important as grain and forage crops in regions of slight or moderate rainfall and high summer temperatures. As they are of tropical origin they can not be grown in the extreme north or at high altitudes. Although some progress has been made in securing early strains, at the present time they can hardly be depended on to mature seed very far north of the southern boundary of Nebraska. Some of the varieties are of value as forage crops, however, for a considerable distance farther north. In all the middle and southern portion of the Great Plains, in the semiarid Southwest, and in the central valleys of California these sorghums make the most acceptable substitutes for corn which can be grown. They are especially valuable for growing on "new land." Kafir corn is most useful in Kansas, especially the western two-thirds of the State, and in Oklahoma and Texas. Yellow milo, owing to its earlier maturity and greater drought resistance, is of value at higher altitudes and in drier sections than Kafir corn. The region best adapted to milo includes the Panhandle section of Texas, the western portion of that State, western Oklahoma, western Kansas, eastern Colorado, and portions of New Mexico. Milo is a promising crop in southern Nebraska and wherever a dry land crop is desired in the Southwest.

In the central valleys of California there is some demand for a crop which can be planted after wheat and barley are harvested and which will furnish fodder and grain with little or no irrigation. The nonsaccharine sorghums best fill these requirements. Jerusalem corn and brown dura are the sorts most largely grown. These varieties are of little value as forage, however, and it is probable that an early-maturing strain of Kafir corn could be introduced to advantage.

ACREAGE GROWN.

As the acreage of nonsaccharine sorghums is not reported by the Bureau of Statistics, and as the reports of the Bureau of the Census do not fully differentiate between the saccharine and nonsaccharine varieties, it is impossible to give the exact acreage of these crops in the United States. However, the production in Kansas and Oklahoma is reported by the boards of agriculture of those States, and from their figures a fairly accurate estimate of the acreage of the entire country may be made. It is probable that from 1,400,000 to 1,600,000 acres are devoted to nonsaccharine sorghums annually and that the crop produced is worth from 12 million to 15 million dollars.

In Kansas at the present time from 500,000 to 550,000 acres of

Kafir corn are grown, the crop being excelled in importance only by corn and wheat. The acreage is considerably increased in dry years, when the acreage of corn is reduced, or when winter wheat fails in the western and central portions of the State. In addition, about 20,000 acres of milo and 2,000 acres of Jerusalem corn are grown annually. The maximum production of nonsaccharine sorghums in Kansas to date was reached in 1902, when nearly 800,000 acres were devoted to these crops. In Oklahoma the annual acreage of Kafir corn is from 300,000 to 350,000, with an additional 150,000 acres in milo. No accurate figures on the production of these crops in Texas are available, but it is probable that the acreage in Oklahoma is at least equaled. The nonsaccharine sorghums are not important in the other States except in California, which annually produces about 50,000 acres of "Egyptian corn."

SOILS ADAPTED TO THE CROP.

The sorghums grow well on almost any good tillable land. Any soil which would be considered good for corn should produce profitable crops of the varieties here discussed. In general, a soil containing some sand is considered more drought resistant than are the finer clays; consequently, a sandy loam or a clay loam containing a small percentage of sand will usually be found most satisfactory. The "red land" section of Oklahoma and northern Texas is specially adapted to these crops. A very light sand is not desirable, nor is a very heavy clay. While the roots of Kafir corn and milo do not penetrate to any great depth, they fill the upper three feet of soil quite completely. They are thus enabled to secure a large part of the available plant food in the soil and make fair crops on rather poor land; the additional returns secured on good land are sufficient however, to justify its use for growing the sorghums. Manure can be used with profit on fields which have been in cultivation for some time or on light sandy soils. On newly broken sod these sorghums usually make fair yields with very little cultivation and are among the best crops for planting on "new land" in the Southwest.

DROUGHT RESISTANCE.

All the varieties of nonsaccharine sorghums are decidedly drought resistant, although there is considerable variation in their power to withstand long periods of dry weather. The sorghums, by reason of their numerous small roots, have the power to take up a greater percentage of the soil moisture than most other plants. They also apparently make better use of this moisture than do many of the other cultivated crops. Some of the varieties of nonsaccharine sorghum, especially milo and Kafir corn, are better able to withstand drought than are the saccharine sorts. These plants are also remarkably resistant to injury from hot, drying winds, and if favorable conditions follow a period of drought they resume growth quickly.

ALKALI RESISTANCE.

In sections where injurious salts are present in the soil, it is generally recognized that the various sorghums are strongly alkali resistant. In Egypt the sorghums are among the first crops planted on alkali land when an attempt is made to reclaim it. In alkali regions in the Southwest they will grow and make fair yields where most other crops fail. Sorghum will withstand greater amounts of alkali than any other important field crop with the exception of well-established alfalfa. Young alfalfa, however, is much more readily killed by alkali than is sorghum.

EFFECT OF SORGHUMS ON THE LAND.

The sorghums are generally considered exhausting in their demands on the soil and injurious in their effect on succeeding crops. They are vigorous-growing, comparatively shallow-rooting plants, which draw quite heavily on the fertility of the surface soil; but in reality they take little more plant food than a corn crop of equal tonnage. The principal injury to the following crop, where any occurs, is usually due to the bad physical condition in which the soil is left by the sorghum. This crop makes its growth late in the season and at that time draws heavily upon the soil moisture. The soil when plowed turns up rough and cloddy and is not in good condition to absorb moisture or to retain it. As the water supply in the sections where sorghum is important is frequently not more than sufficient under the best conditions for crop growth, the succeeding crop suffers materially from lack of moisture. If the soil is properly plowed and placed in good mechanical condition, little injury usually results.

Where the stalks are large and the stubble is likely to prove troublesome, the stubs may be turned out as soon as the crop is cut by running a small plow under them or by disking. If the stubble is plowed out, the clods should be broken with a harrow or clod crusher and the field then plowed deep enough to turn the stubs under. Figure 4 shows a field after the first plowing. Whenever possible, sorghum stubble should be plowed in the autumn, as the action of the frost tends to break up the clods. If the field is to be sown to fall grain, it can usually be put in better condition by thorough disking than by plowing and harrowing. The sowing of small grain after any of the sorghums is a practice which can not be generally recommended, especially where the rainfall is not abundant.

PREPARATION OF THE SOIL.

Land for planting to sorghum should be broken from 5 to 8 inches deep, if possible some weeks before planting.[a] Fall plowing is of advantage where practicable, as the soil is then in best condition to absorb any rain which may fall either before or after planting. However, good crops of Kafir corn and milo are grown by dropping the seed in every third furrow while breaking new land, the sod being turned only 2 or 3 inches. When planted in this way no cultivation is given. Under most conditions the increased yield of fodder and grain will repay any extra effort made in the preparation of the land and the cultivation of the crop. Before planting time the field should be harrowed so as to make the land smooth and mellow, secure a good seed bed, and kill any weeds which may have started. As the sorghum plants grow very slowly for some weeks after germination it is important to have the field as clean as possible at planting time.

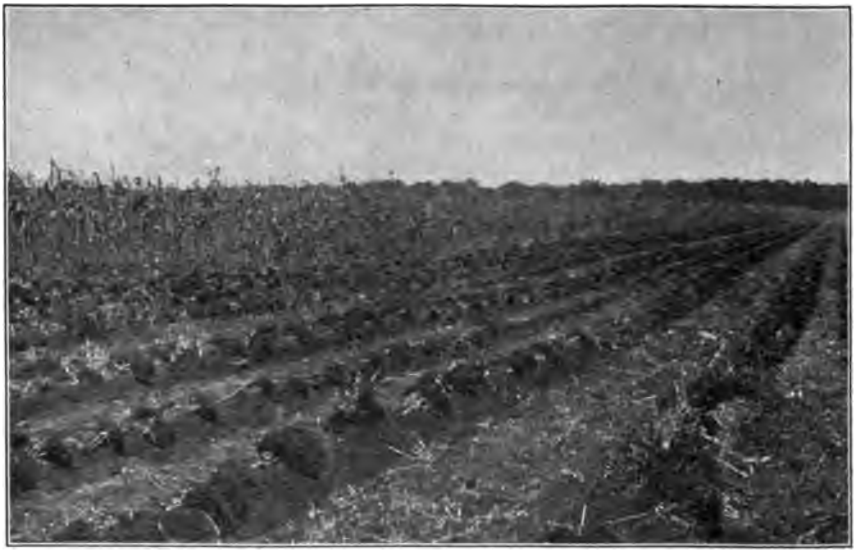


FIG. 4.—Field showing sorghum stubs plowed out.

In California and in other sections where irrigation is practiced, it is customary to irrigate the land before plowing, then plow and harrow, and plant the seed as soon thereafter as possible. Occasionally a second irrigation is given later in the season, but more frequently the crop is grown with but a single watering and without cultivation.

---

[a] Farmers' Bulletin No. 266, entitled "Management of Soils to Conserve Moisture, with Special Reference to Semiarid Conditions," contains a very complete discussion of the preparation of the soil and the cultivation of crops in the sections where the nonsaccharine sorghums are important.

PLANTING.

DATE OF PLANTING.

As the sorghums grow best in warm weather, the seed should not be planted until all danger from frost is past and the soil is thoroughly warm. In general, about fifteen or twenty days after the time for corn planting may be considered safe. In the South early seeding is usually desirable, as the first crop matures soon enough to secure a second crop of fodder and sometimes a second crop of grain. Where Kafir corn and milo are grown on a large scale it is customary to continue the planting over a considerable period in order to extend the harvesting season. Milo can be planted at least ten days later than Kafir corn on account of its earlier maturity. In California, Egyptian corn is usually grown on land where barley or wheat has been harvested, so that planting is generally delayed until June.

QUANTITY OF SEED NECESSARY.

The quantity of Kafir corn seed to plant to the acre varies according to the method of planting, the use to be made of the crop, and the conditions under which it is grown. When grown in rows for the maximum yield of both fodder and grain, 6 or 8 pounds to the acre in 3½-foot rows are desirable, although this quantity is frequently reduced to 3 or 4 pounds. Thin planting, however, produces coarse stalks which are not readily eaten by stock and a small number of large heads which yield less grain than the many small ones resulting from thicker seeding. When the stalks are a considerable distance apart, the heads frequently do not grow entirely out of the "boot", or sheath, and the inclosed part of the head rots or fails to mature seed. Where the crop is to be harvested by hand, thin planting is desirable. For hay and pasture it should be much thicker—one-half to 1 bushel of seed to the acre in rows or drills and 1 to 2 bushels in broadcast seeding. On account of the larger seed of the dura group, heavier planting is necessary—9 to 12 pounds per acre in rows or 1 to 1½ bushels in drills. As thin planting tends to produce goosenecked heads in this class of sorghums, it is never desirable. The largest yields of grain from all varieties may be secured from 3 to 3½ foot rows, with the stalks 2½ to 4 inches apart in the row. In very dry localities, or where the crop receives little cultivation, the stalks should be thinner than where conditions are more favorable.

METHODS OF PLANTING.

Listing.—In the sections of Kansas, Oklahoma, and Texas where the nonsaccharine sorghums are largely grown, the common method of planting all the cultivated crops is with the lister. With this implement the seed is planted in the bottom of a furrow, and is thus placed several inches below the general level of the field. This furrow is filled by the first two cultivations. Listed crops are said to be better able to resist drought than are the surface-planted ones because their main root system is farther below the surface of the soil. Corn and the sorghums, however, throw out many feeding roots from the portion of the stalk covered by cultivation, so that there is really little difference in the depth of the main roots of listed and shallow-planted crops.

The principal advantage from listing comes in the protection afforded the young plants from the strong winds often prevailing in the spring, and from the sand carried by these winds, which sometimes cuts the plants off close to the ground. Listing the crop delays its maturity several days, as the young plants in the bottom of the furrow are checked by lack of heat and light, and it is therefore not to be recommended in sections where the growing season is short or when the seed is planted late. In wet seasons listing is a disadvantage, as the furrow fills with water and the young crop is washed out or covered with sand and mud. If the plants are not yet up, the bottom of the furrow sometimes bakes so hard that they are not able to break through the crust. In listing it is customary to use a planter with special sorghum plates. The most common implement is the combined lister and planter.

Surface planting.—Recent tests have shown that in many sections where the lister is largely used fully as good yields may be secured from surface planting. In surface planting, the ordinary two-row corn planter may be used when provided with sorghum plates, or enough of the holes in a grain drill may be stopped to give the desired distance between the rows. The grain drill distributes the seed rather more evenly along the row than the planter. If the corn planter is used and the drills are desired closer than 3½ feet, the rows may be straddled.

Drilling and broadcasting.—When the crop is desired for hay or pasture, good results can be secured by sowing the seed with a grain drill with all the holes open, or by broadcasting. If the seed is sown broadcast it may be covered by harrowing or disking.

CULTIVATION.

When the crop has been listed, the first cultivation is usually given by running a harrow lengthwise of the rows. The young sorghum plants grow very slowly at first, so that frequent and shallow cultivation is necessary to keep the weeds in check. Harrowing in the direction of the rows throws only a small quantity of earth into the lister furrows, and does not cover the young plants. The harrow may be used until the plants reach the top of the lister furrow, or what is known as the "sled," or lister cultivator, may be substituted. One type of this cultivator is shown in figure 5. In other styles of this machine the knives are replaced by disks. After the plants get above the general level of the field any ordinary type of cultivator can be used to advantage. While the plants are small and before the roots spread into the space between the rows, one cultivation 3½ to 4 inches deep should be given. Later cultivation should be frequent and shallow, to maintain an earth mulch and check evaporation.

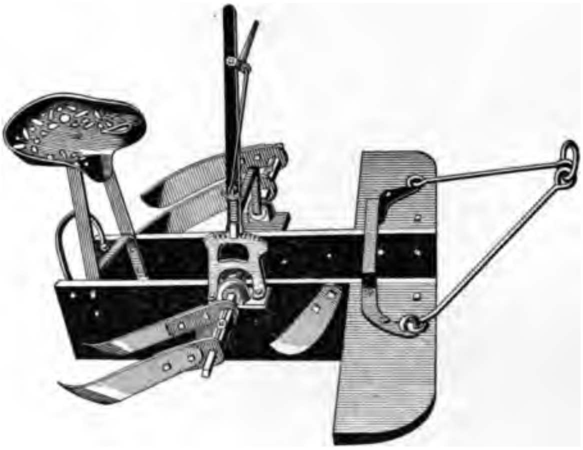


FIG. 5.—A lister cultivator.

When the crop is surface planted the harrow is the best tool for early cultivation, running the same way as the rows. Later tillage should be the same as for the listed crop, using any of the ordinary types of walking or riding cultivators. Frequent cultivation is essential when the plants are small, especially on fields that have been cropped for some years. On sod land good crops are usually grown with only one or two cultivations, or with none at all. In California, where irrigation is practiced, the common method is to grow the crop without cultivation, but one or two workings greatly increase the yield.

Where the crop is drilled, harrowing when the plants are from 3 inches to a foot high is frequently of benefit.

HARVESTING.

When the crop is cut for fodder the grain should be fairly mature; if the heads only are removed they should be fully ripe. For hay the crop may be cut at any period of growth from the time the plant comes into bloom until the seed is in the hard dough stage. For silage it should be harvested when the grain is in the dough stage. If used as a soiling crop, the stalks may be cut at any time after they are large enough to handle conveniently, but can be fed with most profit from the time the plant comes into bloom until it approaches maturity.

When grown in rows the crop is ordinarily harvested with a corn binder and put in large shocks to cure. It can later be thrashed for grain or fed as fodder. A common type of corn harvester is shown in figure 6, while figure 7 shows a field of Kafir corn in shock. The stalks may also be cut with the "sled-cutter" commonly used in the corn belt before the row harvester was introduced, or by hand with a corn knife. Where a large area is to be harvested the saving effected by the use of the most improved machinery fully justifies any additional expense in its purchase.

Ordinarily, when the crop is to be fed without thrashing, the fodder is allowed to stand in the shock until wanted. As the loss from handling in this way is slight, owing to the dry climate, the method is quite practical; but it is advisable to stack a portion of the crop near the feed lot for feeding in stormy weather or when the shocks are covered with snow. A handy rack for hauling the fodder from the field is shown in figure 8. When the fodder is to be hauled a considerable distance before feeding and it is not too tall and coarse it is sometimes baled for convenience in handling. The bundles are not opened in baling, but are simply compressed and bound together. For this purpose a hop baler is the most practical machine, as the ordinary hay presses are too small for compressing the bundles.

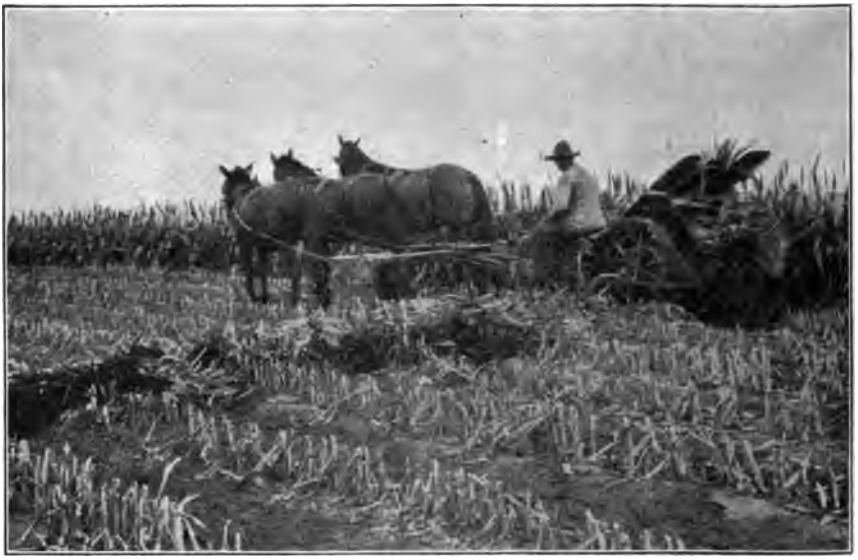


FIG. 6.—Cutting Kafir corn with a row binder.

Where the fodder is not desired the heads may be removed by hand, using an ordinary pocket or butcher knife, or by a special header attached to the wagon box and driven by a sprocket on the rear wheel of the wagon. A header of this sort is shown in figure 9. When the crop is harvested in this way the heads should not be thrown in piles unless they are thoroughly dry, as they heat quickly if at all damp or green. If the heads are not dry when harvested they should be spread in thin layers to cure.

If the crop is drilled or sown broadcast it may be cut with an ordinary grain harvester. For this purpose it is customary to use an open-end elevator. When the crop is sown in this way the heads can be removed with a grain header. The stalks may then be cut and stacked for stover or they may be pastured. When cut for hay a mower is generally used; the hay is allowed to cure partially in the swath, then raked into windrows, where the curing is completed, and stacked with a sweep rake and swinging stacker. Under favorable conditions the hay will cure in three or four days.

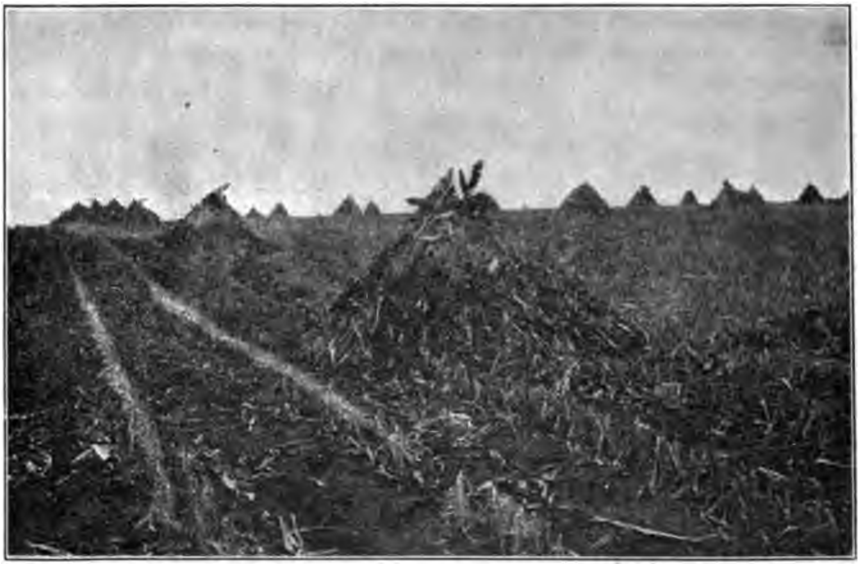


FIG. 7.—Field of White Kafir corn in shock.

THRASHING.

If the grain is to be fed alone, the fodder may be run through an ordinary thrasher with the concaves removed and boards substituted, or the heads only may be inserted, the grain thrashed out, and the stalks then removed. Both these operations involve much heavy labor, however. A better way is to remove the heads from the stalks and run only the heads through the machine. If the crop is cut for fodder the heads may be removed by hand, using an ordinary knife, or by laying the bundle on a block and cutting them off with a broadax or corn knife. The seed should be thoroughly dry when thrashed; if it is not, it should be spread in thin layers to dry, as it heats quickly if stored in bins when damp. The grain also absorbs moisture readily, so that in damp weather it is necessary to shovel it over occasionally.

YIELDS.

The yield of thrashed grain usually secured varies from 25 to 50 bushels to the acre, although considerably larger crops have been reported. On upland at the Kansas Agricultural Experiment Station, Kafir corn averaged 46 bushels per acre and corn 34½ bushels in a test covering eleven years. Results secured at the Oklahoma Agricultural Experiment Station are equally favorable to Kafir corn, both in yield of grain and fodder. Farther west, in the region better adapted to the sorghums and less favorable to corn, the comparison is more decidedly advantageous to Kafir corn. White Kafir corn yields rather more than the red variety, and yellow milo is the heaviest yielder of the dura type. The usual return secured in California from Jerusalem corn and dura (Egyptian corn) with one irrigation and no cultivation is about 25 or 30 bushels. Where an additional irrigation and one or two cultivations are given, twice this yield is frequently secured. These figures are on the basis of the standard weight, 56 pounds of seed to the bushel.

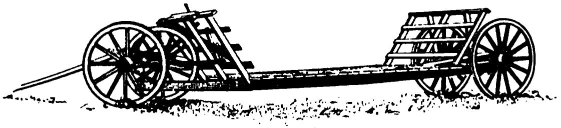


FIG. 8.—A convenient rack for hauling fodder.

The yield of fodder secured varies with the method of planting, the thickness of the stand, the soil, and the season. Under favorable conditions, yields of 4 to 6 tons of cured fodder can be obtained from Kafir corn, and 2½ to 4 tons from the dura group. Sorghums of the dura group do not contain as much juice as Kafir corn, and hence the same bulk of dry fodder is much lighter. The usual yield of hay or fodder under ordinary conditions from all the nonsaccharine sorghums varies from 2 to 5 tons. The yield of green fodder or silage ranges from 6 to 12 tons ordinarily, but as much as 20 tons to the acre is sometimes obtained under very favorable conditions.

UTILIZATION OF THE CROP.

FODDER.

Kafir corn fodder (stalks before the heads are removed) has about the same feeding value as corn fodder, and can be used in the same way. Fodder from the other nonsaccharine varieties is rather less palatable than that from Kafir corn, and consequently ranks lower in feeding value. Brown dura and Jerusalem corn stalks are dry and pithy and do not make as good feed as yellow milo. Fodder from the better varieties of nonsaccharine sorghum makes excellent roughage for "wintering over" stock cattle or for feeding in addition to grain to fattening stock. With bran, alfalfa hay, or some other feed rich in protein, it is a good milk producer when fed to dairy cows. If the fodder is at all moldy or dusty, it should be fed after milking; otherwise the quality of the milk will be affected by the dirt and odor.

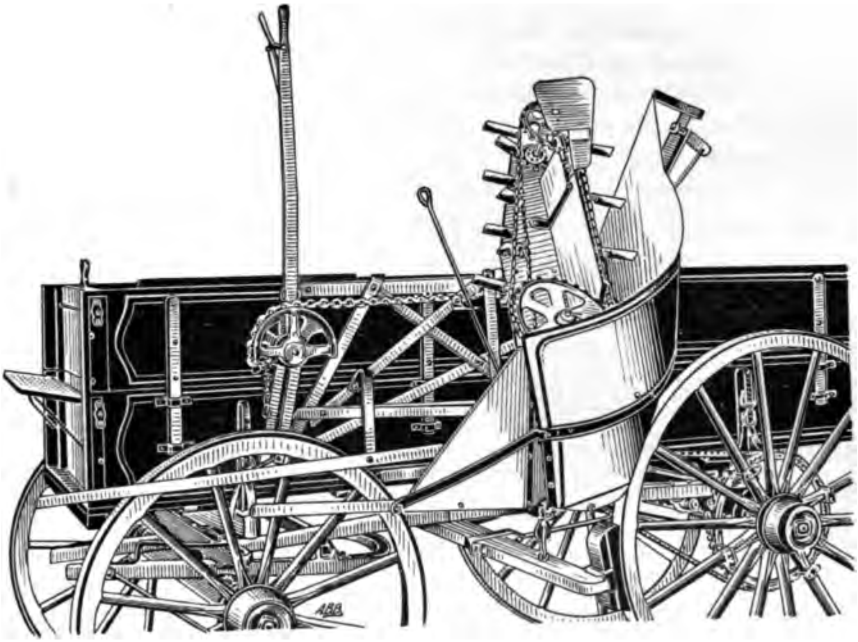


FIG. 9.—A Kafir corn header.

Although sorghum stover (stalks with the heads removed) is much lower in feeding value than the fodder, it is nearly as good as corn stover, and makes good roughage to feed with grain and alfalfa hay or as part of a maintenance ration for stock cattle. The stalks remaining in the field after the crop has been headed may be utilized by cutting and feeding as stover or by pasturing. The stalks of Egyptian corn are usually considered of little value.

While there may be some slight advantage in shredding fodder of the nonsaccharine sorghums, yet the gain is usually not enough to justify this expense. Practically the same result is accomplished by running the stalks through a thrasher, and this method puts the stover in excellent shape for feeding.

HAY.

The nonsaccharine varieties are not commonly used as hay crops, the saccharine sorts usually being sown when hay is desired. Kafir corn, however, makes excellent hay, which is fully equal to good sorghum or nearly equal to timothy for feeding. The other varieties of nonsaccharine sorghum are seldom grown as hay crops. The hay has about the same feeding value as the fodder, except that on account of the smaller stems stock eat it better and there is less waste. On the other hand, little seed is usually formed and the crop is cut before this is fully developed, so that there is a loss in the feeding value in this respect.

PASTURE.

The nonsaccharine sorghums make fair pasture crops, but are not usually considered equal to the best of the saccharine varieties for this purpose. Kafir corn makes better pasture than any of the other nonsaccharine sorts. Not less than a bushel of seed to the acre should be drilled in on well-prepared ground. Pasturing may begin when the plants are only a few inches high, but for the best results the crop should be allowed to grow at least 3 feet high before stock is turned into the field. They should be gradually accustomed to the feed by leaving them on it for only a short time during the first few days. When the crop is grown as pasture for hogs they should be turned in when it is about 18 inches high.

The sorghums should be available for pasture in about fifty or sixty days after sowing the seed, and will remain in good condition for at least thirty days. An acre of good Kafir corn will produce pasturage for 10 head of cattle eight to ten days. Under favorable conditions, if the cattle are taken off the field after the crop has been pastured down, it will make sufficient second growth in a month or six weeks to furnish considerable additional pasture.

In California, especially in the vicinity of Bakersfield, cattle are sometimes fattened by turning them into fields of mature dura or Jerusalem corn. These cattle have been pastured on alfalfa during the summer, and usually have the run of alfalfa pasture in addition to Egyptian corn when fattening. The results secured from feeding in this manner have been very satisfactory. The practice of pasturing the mature crop where alfalfa is not available can not be generally recommended.

Danger from poisoning.—The chief danger to cattle in pasturing on sorghum of any kind is from poisoning. Stunted plants, especially after a period of warm, dry weather, sometimes store up prussic acid in the leaves in sufficient quantity to cause death to cattle within a short time. Normal growth seldom contains injurious amounts of this substance. If by accident stock is poisoned from eating sorghum, the administration of large quantities of glucose (corn sirup or molasses) or of milk will frequently give relief. In curing, the prussic acid disappears, so that there is no danger from this source in feeding the hay or fodder.

SILAGE AND SOILING.

The nonsaccharine sorghums are little used for silage or for soiling, as these methods of feeding are not commonly practiced in the sections where they are grown. In sections adapted to their growth Kafir corn and milo will make rather better silage than the saccharine sorghums, as they contain less sweet juice and the percentage of grain to the whole plant is considerably greater. The abundance of sweet juice in the saccharine sorghums sometimes causes the silage to become quite sour and gives it a very disagreeable odor.

As a soiling crop the sorghums are desirable because they are available during July, August, and September, when most other crops are not in condition for feeding. They are specially valuable during a period of drought, when pastures are short, as they are little affected by dry weather and furnish a large quantity of succulent feed when it is most needed. The saccharine varieties are usually considered rather better than the nonsaccharine ones for soiling.

GRAIN.

Feed for cattle.—Numerous tests have shown that the most economical way of utilizing the grain of the nonsaccharine sorghums as a fattening ration is to thrash and grind or crush it, feeding with alfalfa hay or some other feed containing a considerable percentage of protein, such as cotton-seed meal or cake. The seeds of the sorghums are very rich in carbohydrates, or fat-forming materials, but are low in protein. The feeding of additional protein usually greatly reduces the cost of the gains secured. The amount required is comparatively slight, however. In a test conducted by J. J. Edgerton for the Texas Agricultural Experiment Station, using ground Kafir corn and milo and cotton-seed cake, with sorghum hay as roughage, better and more economical gains were secured from a ration containing 8.5 per cent of cotton-seed cake than from one containing about one-third more of the cake. As Kafir grain is constipating when fed in considerable quantities, it is advisable to feed with alfalfa hay, cotton-seed cake, or milo grain, all of which tend to counteract this condition. With hogs following the cattle the loss from unground grain is partially recovered, but the feeding of the whole grain in large quantities is not advisable under any circumstances.

As a maintenance ration a small quantity of the grain may be fed with the stover, or the fodder may be fed. Probably this latter method is the more economical, especially if hogs follow the cattle. For feeding to dairy cows, the most economical ration where alfalfa is produced is alfalfa hay and Kafir corn or milo grain. Kafir corn is better than milo for feeding to calves with skim milk, as the constipating effect of the Kafir corn checks any opposite tendency due to the milk.

Feed for hogs.—The Kansas and Oklahoma agricultural experiment stations have shown that ground Kafir corn is nearly equal to corn meal as a fattening ration for hogs. The most economical gains at the Kansas station were secured by feeding a ration containing a small proportion of some feed rich in protein. No accurate tests have been made of the grain of the other nonsaccharine varieties for hog feeding, but there is no reason why they should not give fully as satisfactory returns as Kafir corn. Hogs soon tire of Kafir meal when it is fed alone, but when fed with alfalfa hay or some other feed high in protein, or when the hogs have the range of alfalfa pasture, they eat the Kafir corn as readily as corn. Dry, whole Kafir corn has proved a more satisfactory feed than the soaked grain, but wet Kafir meal has given slightly better returns than dry meal. Excellent results have been secured from feeding Kafir meal moistened with skim milk, as the skim milk provides the necessary protein in addition to making the meal more palatable.

Feed for sheep.—Very few tests have been conducted by the agricultural experiment stations in the feeding of these grains to sheep, nor have many farmers had experience along this line. Tests made by the Kansas Agricultural Experiment Station have shown practically the same gains from feeding Kafir meal as from shelled corn, alfalfa hay being used as roughage in both cases. The grain should be ground for feeding to sheep. Feeders in the Texas Panhandle, however, have secured quite satisfactory results from feeding the grain in the head, using millet and sorghum hay as roughage.

Feed for horses.—Kafir corn and milo are usually considered rather less heating than corn, and for that reason make better feed for horses during hot weather or when the animals are doing hard work. Kafir corn is an excellent grain to feed with alfalfa hay, as it counteracts the loosening effect of the hay on the bowels. Where both milo and Kafir corn are largely grown, farmers differ as to which is the better grain for horse feed. It is probable that a mixture of the two is slightly better than either alone. The usual practice is to feed the grain in the head, though it is sometimes thrashed or crushed. Considerable waste will be prevented if the heads are run through a cutter before feeding. The fiber helps to lighten the ration and make the grain more digestible.

Feed for poultry.—The seed of all the nonsaccharine sorghums ranks high as poultry food. For fattening fowls the grain is about equal to corn and is much superior for feeding to laying hens. . As the fowls get considerable exercise in picking the grain out of the heads, it should not be thrashed for feeding to breeding stock. In feeding the thrashed seed the best plan is to scatter it in straw or litter, thus causing the poultry to scratch for it. The thrashed grain should be used for feeding to fowls which are being fattened. Seed of the various sorghums forms a large part of many of the poultry feeds on the market.

THE GRAIN AS FOOD FOR MAN.

In the United States the grain of the nonsaccharine sorghums is not used to any great extent as food for man, although occasionally the meal is made into cakes or bread. White Kafir corn in particular makes a very good quality of meal and can be used like corn meal for all purposes. The milling of these grains has received little attention, but the possibilities of their use as food for man are considerable. In many parts of Asia and in central and southern Africa the seed of the various sorghums is largely produced for human consumption and forms as large a part of the food supply of the people as do rice and wheat in other sections.

FEEDING VALUE AND CHEMICAL ANALYSES.

Chemical analyses show that the nonsaccharine sorghums compare very favorably with corn, both as to grain and fodder. The fodder, in the green state and when cured, shows almost exactly the same amount of the various constitutents as corn, and there is little difference in the digestibility of the two fodders. The heads of the nonsaccharine sorghums contain rather more water and crude fiber than ear corn, and weight for weight have considerably less value as feed. Analyses indicate that the grain is only slightly less valuable than shelled corn, but tests have shown that it is somewhat less digestible even when ground, on account of its hard, flinty character. In many feeding tests Kafir corn and milo have proved to be worth from four-fifths to seven-eighths as much as corn; that is, from four-fifths to seven-eighths of a bushel of corn equals in feeding value 1 bushel of the nonsaccharine sorghums. According to these figures the sorghums are worth 32 to 35 cents when corn is worth 40 cents, and 48 to 53 cents when corn is worth 60 cents a bushel. Figured on the basis of 100 pounds of each grain, the sorghums are worth 60 to 65 cents when corn is worth 75 cents, and 80 to 87 cents when corn is worth $1.

MARKET FOR THE SEED.

Until two or three years ago there was very little demand for the grain produced by the nonsaccharine sorghums. Of late, however, a fair market has been built up, particularly for Kafir corn. Milo and the other sorghums are not yet much in demand except in a local way. In seasons when feed is scarce on the range the cattle men pay good prices for both the fodder and grain. The ruling prices for Kafir corn are much lower than for corn—frequently not more than half, a discrimination which is not justified by the difference in the feeding value of the two grains. In California the grain is usually worth nearly as much as corn. The Kafir corn which goes on the market is used in the making of poultry feed or is ground and sold as Kafir chop. It is also said to be used as an adulterant in corn chop, in shorts, and even in the lower grades of wheat flour. It is probable that some of it is used in the manufacture of certain brands of prepared breakfast foods.

DISEASES AND INJURIOUS INSECTS.

The principal disease which attacks the nonsaccharine sorghums is the grain smut of sorghum. This is quite prevalent and often destroys as much as 5 or 10 per cent of the crop. It may be kept in check by soaking the seed in hot water (132° to 134° F.) for fifteen minutes.[a] This destroys the smut spores, but does not injure the seed. The grain should be dried immediately after the treatment. So far as the writer has observed, yellow milo is free from this disease. There is another smut which sometimes attacks the sorghums, known as the whole-head smut, which is similar to that affecting corn. This disease is most easily checked by seed selection. There are several other diseases which are occasionally present, but they seldom do serious damage.

A trouble sometimes experienced in wet seasons is the failure of the sorghums of all sorts to form seed. The injury is probably due to "scalding," which occurs during a period of hot, sunshiny weather immediately following a rain. The only preventive measure which can be taken is to make several plantings, so that they will come into bloom at different dates and a part of the crop thus escape the unfavorable weather conditions.

---

[a] The details of several methods of treating smut may be found in Farmers' Bulletin No. 250, "The Prevention of Stinking Smut of Wheat and Loose Smut of Oats." The same methods may be used in the treatment of sorghum smut.

Along the eastern border of the section where these crops are important, chinch bugs are often quite destructive. The sorghums are dense and succulent and furnish shade and food for the bugs when they are driven from the grain fields by the ripening and harvesting of the grain. Remedies for the chinch bug are discussed in Farmers' Bulletin No. 132.

IMPROVEMENT OF THE CROP.

The usual method of securing seed for planting is to take the thrashed grain from the bin or the heads as they come from the field. The yield of grain and fodder may be considerably increased by intelligent selection of the seed heads. In many sections it is desirable to increase the earliness of the crop. This may be accomplished by selecting the earliest maturing desirable heads in the field and planting these separate from the main crop. By selecting the early heads from this plot for two or three years a very material gain in earliness can be effected. In the same way desired results in increasing the size of the grain, the size of the head, the percentage of grain to the head or to the whole plant, or any other particular may be secured.

The desirable type for the production of both grain and fodder in Kafir corn is a stalk of medium height, juicy and sweet, without suckers or side branches, with a large number of broad leaves, and bearing a good-sized head well filled with grain. In the dura group a very desirable characteristic to be brought out is erectness of heads. In addition, the stalks should be of moderate height, uniform, quite juicy, leafy, and bearing a good-sized, rather open head well filled with large grain.

All the varieties of sorghum cross very readily, as the flowers are fertilized to some extent by pollen carried by the wind or by insects. For this reason the seed plot should be a considerable distance from any other variety of sorghum. The fact that the plants are frequently cross-pollinated gives an additional reason for selecting the best seed heads and growing a special seed plot. Under field conditions any variety of sorghum will soon become mixed by means of pollen blown from adjoining fields, and the crop will be irregular in height and maturity. The tall stalks shown in figure 7 are the result of this crossing, although the field illustrated was remarkably free from plants of this kind. The growing of seed as free as possible from this undesirable mixture is strongly to be recommended.

SUMMARY.

There are three distinct classes of sorghums: (1) The broom corns, (2) the saccharine sorghums, and (3) the nonsaccharine sorghums.

The important varieties of nonsaccharine sorghums may be divided into two groups: (1) Kafir corn and (2) the duras.

The varieties of Kafir corn are stocky, leafy, erect-headed sorghums; the dura group usually grows taller, is less leafy, and the heads are often goosenecked.

The nonsaccharine sorghums are important for the production of grain and forage in the semiarid sections of the West and Southwest.

These sorghums will grow on any good soil, but do best on a sandy loam.

All the varieties are remarkably resistant to drought and alkali, though they differ somewhat in their ability to withstand injury from these sources.

The bad effect on the land often attributed to sorghums is due largely to the poor physical condition in which they leave the soil and may be remedied by proper tillage.

The nonsaccharine sorghums should be planted two or three weeks later than corn, the quantity of seed and the method of planting varying with the section and the use that is to be made of the crop.

Frequent cultivation is desirable to keep down weeds and prevent evaporation of soil moisture.

The crop is usually harvested with a row binder, but may be cut by hand with a sled cutter, or in a number of other ways.

The crop may be headed and the heads thrashed, or the whole plant may be run through the thrasher.

Yields of 25 to 50 bushels of grain and 2 to 5 tons of dry fodder may ordinarily be expected.

The nonsaccharine sorghums may be fed as fodder or hay, as silage or as soiling crops; they may be pastured, and the grain may be fed to all kinds of stock. When fed in any of these ways, they compare very favorably with corn in food value. A bushel of the grain is worth about four-fifths as much as a bushel of corn from the standpoint of nutrition.

Chemical analyses indicate that the grain and fodder are about equal in feeding value to corn, but are slightly less digestible.

The prices usually offered for the grain are much less than it is really worth when compared with corn.

The earliness, quality, and yield of the crop may be greatly influenced by careful selection of the seed.

FARMERS' BULLETINS.

The following is a list of the Farmers' Bulletins available for distribution, showing the number, title, and size in pages of each. Copies will be sent free to any address in the United States on application to a Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

22. The Feeding of Farm Animals. Pp. 40.
24. Hog Cholera and Swine Plague. Pp. 16.
25. Peanuts: Culture and Uses. Pp. 24.
27. Flax for Seed and Fiber. Pp. 16.
28. Weeds and How to Kill Them. Pp. 30.
29. Souring and Other Changes in Milk. Pp. 22.
30. Grape Diseases on the Pacific Coast. Pp. 15.
32. Silos and Silage. Pp. 30.
33. Peach Growing for Market. Pp. 24.
34. Meats: Composition and Cooking. Pp. 31.
35. Potato Culture. Pp. 24.
36. Cotton Seed and Its Products. Pp. 16.
39. Onion Culture. Pp. 30.
41. Fowls: Care and Feeding. Pp. 24.
42. Facts About Milk. Pp. 32.
44. Commercial Fertilizers. Pp. 38.
46. Irrigation in Humid Climates. Pp. 27.
47. Insects Affecting the Cotton Plant. Pp. 32.
48. The Manuring of Cotton. Pp. 16.
49. Sheep Feeding. Pp. 24.
51. Standard Varieties of Chickens. Pp. 48.
52. The Sugar Beet. Pp. 48.
54. Some Common Birds. Pp. 48.
55. The Dairy Herd. Pp. 30.
56. Experiment Station Work—I. Pp. 30.
58. The Soy Bean as a Forage Crop. Pp. 24.
59. Bee Keeping. Pp. 48.
60. Methods of Curing Tobacco. Pp. 24.
61. Asparagus Culture. Pp. 40.
62. Marketing Farm Produce. Pp. 31.
63. Care of Milk on the Farm. Pp. 40.
64. Ducks and Geese. Pp. 55.
65. Experiment Station Work—II. Pp. 32.
66. Meadows and Pastures. Pp. 30.
68. The Black Rot of the Cabbage. Pp. 22.
69. Experiment Station Work—III. Pp. 32.
70. Insect Enemies of the Grape. Pp. 23.
71. Essentials in Beef Production. Pp. 24.
72. Cattle Ranges of the Southwest. Pp. 32.
73. Experiment Station Work—IV. Pp. 32.
74. Milk as Food. Pp. 39.
77. The Liming of Soils. Pp. 24.
78. Experiment Station Work—V. Pp. 32.
79. Experiment Station Work—VI. Pp. 27.
80. The Peach Twig-borer. Pp. 16.
81. Corn Culture in the South. Pp. 24.
82. The Culture of Tobacco. Pp. 22.
83. Tobacco Soils. Pp. 23.
84. Experiment Station Work—VII. Pp. 32.
85. Fish as Food. Pp. 32.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
91. Potato Diseases and Treatment. Pp. 15.
92. Experiment Station Work—IX. Pp. 30.
93. Sugar as Food. Pp. 31.
95. Good Roads for Farmers. Pp. 46.
96. Raising Sheep for Mutton. Pp. 48.
97. Experiment Station Work—X. Pp. 32.
98. Suggestions to Southern Farmers. Pp. 48.
99. Insect Enemies of Shade Trees. Pp. 30.
100. Hog Raising in the South. Pp. 40.
101. Millets. Pp. 30.
102. Southern Forage Plants. Pp. 48.
103. Experiment Station Work—XI. Pp. 30.
104. Notes on Frost. Pp. 24.
105. Experiment Station Work—XII. Pp. 32.
106. Breeds of Dairy Cattle. Pp. 48.
107. Experiment Station Work—XIII. Pp. 32.
108. Saltbushes. Pp. 20.
109. Farmers' Reading Courses. Pp. 20.
110. Rice Culture in the United States. Pp. 28.
111. Farmer's Interest in Good Seed. Pp. 24.
112. Bread and Bread Making. Pp. 40.
113. The Apple and How to Grow It. Pp. 32.
114. Experiment Station Work—XIV. Pp. 28.
115. Hop Culture in California. Pp. 28.
116. Irrigation in Fruit Growing. Pp. 48.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 30.
120. Insects Affecting Tobacco. Pp. 32.
121. Beans, Peas, and other Legumes as Food. Pp. 38.
122. Experiment Station Work—XVI. Pp. 32.
124. Experiment Station Work—XVII. Pp. 32.
125. Protection of Food Products from Injurious Temperatures. Pp. 24.
126. Practical Suggestions for Farm Buildings. Pp. 48.
127. Important Insecticides. Pp. 46.
128. Eggs and Their Uses as Food. Pp. 40.
129. Sweet Potatoes. Pp. 40.
131. Household Tests for Detection of Oleomargarine and Renovated Butter. Pp. 10.
132. Insect Enemies of Growing Wheat. Pp. 38.
133. Experiment Station Work—XVIII. Pp. 32.
134. Tree Planting in Rural School Grounds. Pp. 32.
135. Sorghum Sirup Manufacture. Pp. 40.
136. Earth Roads. Pp. 24.
137. The Angora Goat. Pp. 48.
138. Irrigation in Field and Garden. Pp. 40.
139. Emmer: A Grain for the Semiarid Regions. Pp. 16.
140. Pineapple Growing. Pp. 48.
141. Poultry Raising on the Farm. Pp. 16.
142. Principles of Nutrition and Nutritive Value of Food. Pp. 48.
143. Conformation of Beef and Dairy Cattle. Pp. 44.
144. Experiment Station Work—XIX. Pp. 32.
145. Carbon Bisulphid as an Insecticide. Pp. 28.
146. Insecticides and Fungicides. Pp. 16.
147. Winter Forage Crops for the South. Pp. 40.
148. Celery Culture. Pp. 32.
149. Experiment Station Work—XX. Pp. 32.
150. Clearing New Land. Pp. 24.
151. Dairying in the South. Pp. 48.
152. Scabies in Cattle. Pp. 32.
153. Orchard Enemies in the Pacific Northwest. Pp. 39.
154. The Home Fruit Garden: Preparation and Care. Pp. 16.
155. How Insects Affect Health in Rural Districts. Pp. 19.
156. The Home Vineyard. Pp. 22.
157. The Propagation of Plants. Pp. 24.
158. How to Build Small Irrigation Ditches. Pp. 28.
159. Scab in Sheep. Pp. 48.
161. Practical Suggestions for Fruit Growers. Pp. 30.
162. Experiment Station Work—XXI. Pp. 32.
164. Rape as a Forage Crop. Pp. 16.
165. Silkworm Culture. Pp. 32.
166. Cheese Making on the Farm. Pp. 16.
167. Cassava. Pp. 32.
168. Pearl Millet. Pp. 16.
169. Experiment Station Work—XXII. Pp. 32
170. Principles of Horse Feeding. Pp. 44.
172. Scale Insects and Mites on Citrus Trees. Pp. 43.
173. Primer of Forestry. Pp. 48.
174. Broom Corn. Pp. 30.
175. Home Manufacture and Use of Unfermented Grape Juice. Pp. 16.
176. Cranberry Culture. Pp. 20.
177. Squab Raising. Pp. 32.
178. Insects Injurious in Cranberry Culture. Pp. 32.
179. Horseshoeing. Pp. 30.
181. Pruning. Pp. 39.

182. Poultry as Food. Pp. 40.
183. Meat on the Farm: Butchering, Curing, and Keeping. Pp. 37.
184. Marketing Live Stock. Pp. 40.
185. Beautifying the Home Grounds. Pp. 24.
186. Experiment Station Work—XXIII. Pp. 32.
187. Drainage of Farm Lands. Pp. 38.
188. Weeds Used in Medicine. Pp. 45.
190. Experiment Station Work—XXIV. Pp. 32.
192. Barnyard Manure. Pp. 32.
193. Experiment Station Work—XXV. Pp. 32.
194. Alfalfa Seed. Pp. 14.
195. Annual Flowering Plants. Pp. 48.
196. Usefulness of the American Toad. Pp. 16.
197. Importation of Game Birds and Eggs for Propagation. Pp. 30.
198. Strawberries. Pp. 24.
199. Corn Growing. Pp. 32.
200. Turkeys. Pp. 40.
201. Cream Separator on Western Farms. Pp. 23.
202. Experiment Station Work—XXVI. Pp. 32.
203. Canned Fruits, Preserves, and Jellies. Pp. 32.
204. The Cultivation of Mushrooms. Pp. 24.
205. Pig Management. Pp. 40.
206. Milk Fever and Its Treatment. Pp. 16.
208. Varieties of Fruits Recommended for Planting. Pp. 48.
209. Controlling the Boll Weevil in Cotton Seed and at Ginneries. Pp. 32.
210. Experiment Station Work—XXVII. Pp. 32.
211. The Use of Paris Green in Controlling the Cotton Boll Weevil. Pp. 23.
213. Raspberries. Pp. 38.
215. Alfalfa Growing. Pp. 40.
216. The Control of the Boll Weevil. Pp. 32.
217. Essential Steps in Securing an Early Crop of Cotton. Pp. 16.
218. The School Garden. Pp. 40.
219. Lessons from the Grain Rust Epidemic of 1904. Pp. 24.
220. Tomatoes. Pp. 32.
221. Fungous Diseases of the Cranberry. Pp. 16.
222. Experiment Station Work—XXVIII. Pp. 32.
223. Miscellaneous Cotton Insects in Texas. Pp. 24.
224. Canadian Field Peas. Pp. 16.
225. Experiment Station Work—XXIX. Pp. 32.
226. Relation of Coyotes to Stock Raising in the West. Pp. 24.
227. Experiment Station Work—XXX. Pp. 32.
228. Forest Planting and Farm Management. Pp. 22.
229. The Production of Good Seed Corn. Pp. 24.
231. Spraying for Cucumber and Melon Diseases. Pp. 24.
232. Okra: Its Culture and Uses. Pp. 16.
233. Experiment Station Work—XXXI. Pp. 32.
234. The Guinea Fowl. Pp. 24.
235. Preparation of Cement Concrete. Pp. 32.
236. Incubation and Incubators. Pp. 32.
237. Experiment Station Work—XXXII. Pp. 32.
238. Citrus Fruit Growing in the Gulf States. Pp. 48.
239. The Corrosion of Fence Wire. Pp. 32.
240. Inoculation of Legumes. Pp. 8.
241. Butter Making on the Farm. Pp. 32.
242. An Example of Model Farming. Pp. 16.
243. Fungicides and their Use in Preventing Diseases of Fruits. Pp. 32.
244. Experiment Station Work—XXXIII. Pp. 32.
245. Renovation of Worn-out Soils. Pp. 16.
246. Saccharine Sorghums for Forage. Pp. 37.
247. The Control of the Codling Moth and Apple Scab. Pp. 21.
248. The Lawn. Pp. 20.
249. Cereal Breakfast Foods. Pp. 36.
250. The Prevention of Wheat Smut and Loose Smut of Oats. Pp. 16.
251. Experiment Station Work—XXXIV. Pp. 32.
252. Maple Sugar and Sirup. Pp. 36.
253. The Germination of Seed Corn. Pp. 16.
254. Cucumbers. Pp. 30.
255. The Home Vegetable Garden. Pp. 47.
256. Preparation of Vegetables for the Table. Pp. 48.
257. Soil Fertility. Pp. 39.
258. Texas or Tick Fever and Its Prevention. Pp. 45.
259. Experiment Station Work—XXXV. Pp. 32.
260. Seed of Red Clover and Its Impurities. Pp. 24.
261. The Cattle Tick. Pp. 22.
262. Experiment Station Work—XXXVI. Pp. 32.
263. Practical Information for Beginners in Irrigation. Pp. 40.
264. The Brown-tail Moth and How to Control It. Pp. 22.
265. Game Laws for 1906. Pp. 54.
266. Management of Soils to Conserve Moisture. Pp. 30.
267. Experiment Station Work—XXXVII. Pp. 32.
268. Industrial Alcohol: Sources and Manufacture. Pp. 45.
269. Industrial Alcohol: Uses and Statitiscs. Pp. 29.
270. Modern Conveniences for the Farm Home. Pp. 48.
271. Forage Crop Practices in Western Oregon and Western Washington. Pp. 39.
272. A Successful Hog and Seed-Corn Farm. Pp. 16.
273. Experiment Station Work—XXXVIII. Pp. 32.
274. Flax Culture. Pp. 36.
275. The Gypsy Moth and How to Control It.
276. Experiment Station Work—XXXIX. Pp. 32.
277. The Use of Alcohol and Gasoline in Farm Engines. Pp. 40.
278. Leguminous Crops for Green Manuring. (In press.)
279. A Method of Eradicating Johnson Grass. (In press.)
280. A Profitable Tenant Dairy Farm. (In press.)
281. Experiment Station Work—XL. Pp. 32.
282. Celery. (In press.)
283. Spraying for Apple Diseases and the Codling Moth in the Ozarks. (In press.)
284. Insect and Fungous Enemies of the Grape East of the Rocky Mountains. (In press.)
285. The Advantage of Planting Heavy Cotton Seed. (In press.)
286. Comparative Value of Whole Cotton Seed and Cotton-Seed Meal in Fertilizing Cotton. (In press.)
287. Poultry Management. (In press.)
288. Nonsaccharine Sorghums. (In press.)
289. Beans. (In press.)

O

Issued April 30, 1907.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 289.

BEANS.

BY

L. C. CORBETT,
*Horticulturist, in Charge of the Arlington Experimental Farm,
Bureau of Plant Industry.*

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., March 15, 1907.

Sir: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin a manuscript entitled "Beans," prepared by Prof. L. C. Corbett, Horticulturist, in charge of the Arlington Experimental Farm.

Respectfully,
B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.

Introduction 5

Types of beans 6

  Broad beans 6

  Kidney, or Haricot, beans 6

  Lima, or Sugar, beans 6

  Dolichos beans 7

  Soy beans 7

  Scarlet Runner beans 7

  Velvet, or Banana, beans 7

  Cowpeas 7

Field and garden groups 7

Acreage grown 8

Field beans 10

  Preparation of the soil 10

  Planting 12

    Quantity of seed necessary 12

    Depth of planting 13

  Cultivation 13

  Harvesting 14

  Thrashing 16

  Cleaning and grading 17

Garden beans 18

  Soil 20

    Preparation of the soil 21

  Fertilizers 21

  Planting 22

    Quantity of seed necessary 23

  Cultivation 23

  Harvesting 23

  Yield 25

  Lima beans 25

    Planting 26

    Cultivation 27

Diseases and enemies 28

B. P. I.—268.

BEANS.

INTRODUCTION.

The bean belongs to one of the most important families of economic plants with which man has to deal. While there is a great variety of plants belonging to the pulse family, of which the bean is a member, varying in size from low annual plants to tall, broad, spreading trees, there are few members of this group which possess greater economic importance than does the bean. Besides furnishing wholesome, nourishing food for man and for animals, this group of plants provides the agriculturist with a means of securing from the great store of nitrogen in the air, by the use of one of its members in the crop rotation of his farm, a sufficient quantity of nitrogen to replenish that taken from the soil by other agricultural crops. Not all leguminous plants provide food for both man and beast and at the same time increase the fertility of the soil upon which they grow. The bean, however, is one of those which has this capability. It is therefore one of the most desirable crops to use in the farm rotation, as well as in market-garden work.

While the value of beans and peas of various kinds as food for man and stock has been known for many generations, it is within the memory of men now living that the value of these crops as soil renovators and fertility restorers has been definitely proved. Since these facts have become known the value of such crops is being more and more appreciated, and their cultivation, as a result, very greatly extended.

Perhaps no single agricultural crop is of greater economic importance to the people of the United States than cowpeas, yet its cultivation is comparatively recent in this country. Each year the crop is better appreciated, and its area is being rapidly extended. While the cowpea is not a true bean it is a valuable forage crop and a great soil renovator. The seeds are valuable as grain, the hay is equaled only by alfalfa, and as a producer of organic matter for green manuring it is unsurpassed.

The member of this great family with which we have at this time to deal—the bean—is not so valuable from the standpoint of forage or soil renovation, but is among the most valuable members of the great group for the seed which it produces. While the seed is the most important and valuable factor, the power to gather nitrogen and to render the soil better for having been grown upon it is an important consideration and one which should not be overlooked by those interested in maintaining the nitrogen content of the soil.

TYPES OF BEANS.

Under the general term "bean" there are no less than eight distinct species of plants, native to nearly as many distinct sections of the surface of the earth. These eight closely allied plants, descriptions of which follow, are quite universally spoken of as beans, and are deserving of mention in this connection, although not all of them are treated as are the common beans, which is the primary subject of this bulletin.

Broad beans.—The Broad bean (*Vicia faba*) is one of the oldest members of the group of leguminous plants so far as the records of profane history hold information concerning such plants. It is, however, of minor importance within the confines of the United States, although it is a valuable garden as well as agricultural crop in Canada and most European countries. Upon the continent of North America its cultivation is chiefly confined to the Dominion of Canada, where it is grown as a garden crop and as a companion to corn for silage purposes. This plant requires a long, cool summer, and because of the intense heat and protracted periods of drought characteristic of most quarters of the United States, it does not thrive in this country

Kidney, or Haricot, beans.—Kidney beans, known also as Haricot beans, and technically as *Phaseolus vulgaris*, are the common field and garden beans of America. They also enjoy the distinction, so far as records carry evidence upon this point, of being native to the New World. It is the cultivation and uses of this class which are to claim our attention in the present publication.

Lima, or Sugar, beans.—The plants of Lima, or Sugar, beans (*Phaseolus lunatus*) are normally rank-growing climbers, although within recent times a dwarf, nonclimbing variety has been developed. They thrive best on strong, well-enriched lands and under tropical or subtropical conditions.

Dolichos beans.—Two familiar examples of the Dolichos group of beans, which differ slightly from the common beans, are known as the Hyacinth bean and the Asparagus, or French Yard-Long, bean.

Soy beans.—The soy, or soja, bean (*Glycine hispida*), while for generations known and much appreciated in Japan, is a comparatively recent introduction into the United States, and its cultivation has not as yet become general. In Japan it is a valuable food for man as well as for stock, but in the United States it has received little attention for purposes other than the production of forage for cattle and swine. It is destined, however, to become a very important agricultural product in many sections of the United States, both as a grain and forage crop.

Scarlet Runner beans.—The Scarlet Runner bean (*Phaseolus multiflorus*) is a strong-growing climbing plant, used for decorative purposes on account of its clusters of bright blossoms and the high color of the matured pods, which give it an ornamental value of no mean significance.

Velvet, or Banana, beans.—The Velvet, or Banana, bean (*Mucuna utilis*) is one of the most exacting members of the bean family as regards temperature, and as a result in the United States it can only be grown successfully within comparatively narrow limits. In Florida and along the Gulf coast it has in recent years become an important forage as well as green-manuring crop. In those sections of the United States where it can be successfully grown it is a worthy competitor of the cowpea and soy bean.

Cowpeas.—The cowpea (*Vigna sinensis*), because of its bean-like seed and habit of growth, its great economic importance as a forage crop for the production of hay and silage, and its great value as a green manure, should be mentioned in connection with the other plants to which it is so closely related both botanically and economically.

FIELD AND GARDEN GROUPS.

For convenience in reference and for discussion, beans may be divided into two general groups—"field" and "garden" beans—which are by no means distinctly separate either in appearance or in characteristics. Each of these groups can again be divided into bush and pole beans. Bush beans of the field type are recognized, for commercial purposes, under three well-marked types, known as Kidney, Marrow, and Pea beans, each of which may be subdivided into two groups, colored and white. The garden beans, like the field beans, may be divided into bush and pole types; these again into Kidneys and Limas, the term "Kidney" in this case including all of the common garden beans whether of one type or another, and this group may again be divided into wax and green pod. The same subdivision may also be recorded under pole beans, as is suggested in the following classification:

Classification of beans according to groups and types.

Field beans	Bush	Kidney	Colored. White.
		Marrow	Colored. White.
		Pea	Colored. White.
	Pole or corn hill	White or colored.	
Garden beans	Bush	Kidney	Wax. Green pod.
		Lima.	
	Pole	Kidney	Wax. Green pod.
		Lima.	
		Runner (Scarlet Runner).	

ACREAGE GROWN.

There are no statistics available from which to determine the acreage or quantity of beans produced as field beans and as string and garden beans. The census for 1900 gives the area of the bean crop, including both field and garden beans, as 453,867 acres, and the total product is placed at 5,064,844 bushels, an average of 11⅙ bushels per acre. The total amount received by the producers for the crop was $7,634,262, or an average of $1.51 per bushel. In considering this average it must be remembered that the total includes the products of good as well as of poor cultivators and embraces regions in which the crop was a practical failure as well as those in which it was a success. For those States which make bean growing an important industry the average yield to the acre is somewhat higher than is recorded in this general average.

The three States which lead all others in the production of this crop are Michigan, New York, and California, followed by Wisconsin, Maine, Virginia, North Carolina, Tennessee, Missouri, Minnesota, Illinois, Kentucky, New Mexico, and West Virginia. The other States which produce a considerable acreage of garden beans, with the exception of Florida, cultivate less than 3,000 acres. Florida is reported as cultivating 9,189 acres in 1899. The great bulk of this crop reached the market as snap or string beans. Those beans which were not marketed in this way were of course allowed to ripen and represent a small percentage of the total crop of dry beans. The States in which the great bulk of dry or field beans is produced are Michigan, New York, California, and Maine.

The geographical distribution of this crop, as indicated by the census of 1900, is clearly presented in the accompanying map (fig. 1), which shows the counties in the several States where dry beans are grown commercially. This map shows the influence of climate in determining the regions to which this crop is adapted. The high latitude and the peculiar soil conditions of the New England States and of New York and the high latitude of Michigan, Wisconsin, and Minnesota are equally suited for the production of this crop. Another region where there is considerable interest in the culture of this crop is along the Allegheny Mountains from southern Pennsylvania to northern Georgia. In the north-central part of California, in high altitudes, are also important bean-producing centers.

Within the last decade the cultivation of field beans has increased markedly in certain sections of the eastern United States, particularly throughout New York and Michigan. In many areas in these two States beans have become as much a staple crop as was wheat a quarter of a century ago. From an economic standpoint this is a valuable addition to the farm rotation of the region because of the ability of this crop to improve the land upon which it is grown. If for no other reason than this, the bean crop taking the place of wheat in the rotation would be an advantage to the community. Of late years, however, the bean crop has been a more remunerative crop than wheat, which adds a pecuniary reason for growing the crop to the soil-improving value previously noted.

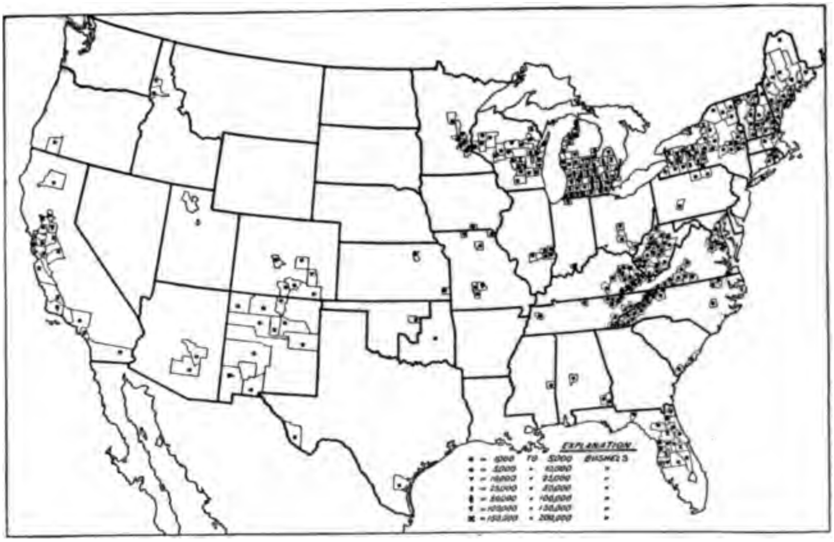


FIG. 1.—Map of the United States showing counties in which dry beans are commercially grown.

While the distribution of field beans is to a very considerable extent determined by soil and climate, the production of garden beans is not so emphatically influenced by these factors. The quick growth of garden beans enables the truck farmer and the market gardener to take advantage of that portion of the year when the climate of the region is most congenial to the production of the crop, and for this reason the demands of the market as well as the location of the grower determine largely the area of garden beans to be grown in any particular locality. Shipping facilities, of course, have as marked an influence upon the distribution of garden beans for early market as upon any other truck crop.

A third rôle in which beans play an important part is that of a product for the canning factory. The production of fresh beans for canning purposes conforms more closely to the area in which field beans are produced than to that where garden beans are grown for early market.

From what has been said, it is evident that there are two important divisions of the bean industry in the United States, namely, the production of field or dry beans and the production of garden beans. The latter involves two industries: (1) The growing of beans for early market, and (2) the raising of string or snap beans for use by the canning factories.

FIELD BEANS.

Reference to the map (fig. 1) giving the distribution of the areas in which beans are commercially cultivated shows that the regions in which the cultivation of this crop is most intensive lie chiefly within the areas covered by the glacial drift of the great ice age. The soils of the area are as a rule strong and retentive, carrying large quantities of lime and considerable potash, phosphoric acid, and organic materials. It is not strange, therefore, that a crop which is able to gather nitrogen from the air should thrive well upon soils having an abundant store of phosphoric acid and potash.

While beans produce abundantly upon strong clay soils, yet the clay loams, shales, and gravelly soils of the drift region are better adapted to the production of this crop than are the heavy clays. The growth of vine is too much restricted upon the very heavy clay soils, and while in proportion to its growth the vines yield well, the total product is in proportion to the growth of the plant as a whole. Figure 2 shows a typical bean field in the North.

PREPARATION OF THE SOIL.

Since the bean is a warm-season crop and can not safely be planted until after danger from killing frost has passed, the preparation of the soil for field beans should be deferred until the vegetation covering the area has made considerable growth, so that it may be as completely destroyed as possible during the operations of plowing, harrowing, and fitting the land for the reception of the seed. The short-season character of the bean crop enables the land to be occupied during the winter months by some cover crop, such as wheat or rye, and if the same land is used year after year for the production of beans, the turning under of winter cover crops furnishes an important means by which the store of organic matter in the soil can be maintained, a consideration of great moment in sections chiefly dependent upon commercial fertilizers as a source for available plant food.

After the land has attained proper dryness in the spring it should be plowed from 6 to 8 inches in depth, and immediately compacted and harrowed, so as to prevent the loss of moisture. The surface of the seed bed should be made smooth and fine, so that the drill or planter can be economically used upon it. If dry weather follows at this season of the year, a good practice is, immediately preceding the planting of the crop, to run a heavy land roller over the area, particularly if the planting is done with an ordinary grain drill. If the planting is done with a planter similar to the ordinary corn planter and the land has been rolled previously, it is advisable to go over it with a spike-tooth harrow or some other type of smoothing harrow after the crop has been planted, in order that the land may not possess a compacted condition from the substratum to the surface.

FIG. 2.—A typical bean field in the North.

The surface mulch which is produced by the use of the smoothing harrow after rolling and planting leaves the soil in the most desirable condition.

PLANTING.

It has already been suggested that field beans should not be planted until all danger from injury by frost has passed. In fact, growers have found that it is better to postpone planting the crop until as late in the season as is practicable and yet be able to safely harvest the crop before the vines are injured by fall frost. The late planted crop has the advantage of escaping the most serious attacks of the bean rust. While there are undoubtedly varieties which are more or less resistant to this trouble, yet the general practice of late planting has been found to be of decided advantage.

In planting the field crop the distance between the rows varies from 28 to 36 inches, according to the implements used in harvesting the crop, 30 inches being a very satisfactory and not an unusual distance for placing the rows. The seeds are so scattered as to fall from 2 to 4 inches apart in the row. The ideal distance would be undoubtedly 6 inches, if it were possible to obtain a perfect stand of plants at this distance. Experiments conducted by the writer and by other investigators have clearly demonstrated that beans planted singly in the row at intervals of from 4 to 6 inches apart produce a much more abundant crop than the same quantity of seed planted in hills from 18 inches to 3 feet apart. For distributing the seed in the row at these distances a bean planter or a check row corn planter may be set to drop the seeds in drills. A common practice is to use an ordinary grain drill and stop a sufficient number of tubes to enable two or three rows of beans to be planted at the proper distance apart without the necessity of purchasing a special implement. By the use of range poles and a 9-tooth drill spaced 8 inches, three rows of beans can be planted each time the field is crossed, leaving the rows 32 inches apart. An 11-tooth drill can be arranged to plant three rows of beans 32 inches apart, if the teeth of the drill are spaced 8 inches, by driving the wheel in the preceding wheel mark on each return trip.

Those contemplating the purchase of implements for different uses should carefully study the adaptability of the implements to the work desired. It will readily be seen that an 11-tooth drill arranged to plant three rows 32 inches apart will be a much more convenient implement than a 9-tooth drill similarly spaced, as the larger implement does away with the necessity for using range poles.

Quantity of seed necessary.—The quantity of seed required to plant an acre of beans varies with the size of the beans; that is, a half-bushel of small Pea beans is sufficient to plant an acre of ground, while a bushel of Red Kidney beans is hardly sufficient to plant an acre when the seed is distributed in the ordinary fashion in drills rather than in hills. In planting beans of the Pea and Marrow types the quantity of seed varies from one-half to a bushel per acre, depending upon the quality of the beans and upon the preferences of the planter. For Kidney beans the quantity varies from a bushel to as much as six pecks per acre. Ordinarily, with rows 30 inches apart, a bushel is a sufficient quantity for seeding an acre.

Depth of planting.—The depth at which beans should be planted is determined by the character of the soil and the season of the year at which they are planted. In heavy, retentive soils planting should be made comparatively shallow, as the peculiar habit of growth of the bean is such that it can not readily reach the surface if planted deep in such soils. Upon light soils and early in the season planting can be made quite deep. Three inches is not too deep upon such soils, but an inch and a half or 2 inches is the maximum depth for planting upon retentive soils. The cowpea is possibly more exacting in regard to the depth of planting than the field bean, the stalk of the young cowpea being more slender and less able to force the seed leaves through any crust of earth that may have formed after planting. All things considered, a satisfactory depth for planting beans is about 1½ inches.

CULTIVATION.

Like all other hoe crops field beans require frequent, shallow cultivation. The stirring of the soil for the purpose of holding the weeds in check and preserving a soil mulch over the area occupied by the growing crop is the important factor to be considered in culture. Implements with narrow blades which stir the soil to a depth of between 2 and 3 inches are most desirable. Those designed for the culture of corn, which are provided with narrow blades such as accompany all implements provided with spring teeth attachments, will be found satisfactory for the cultivation of beans.

At the last cultivation the plants may be slightly hilled; that is, the soil may be thrown toward the plants with small wings. This has the advantage of leaving the plants on a slight ridge, which facilitates the work of harvesting when such work is done by mechanical means. In the cultivation of beans it is traditional that they should not be cultivated when the dew is on the vines. This undoubtedly has a slight foundation for the reason that moisture is a conveyor of spores of disease and might have a tendency to distribute them more widely than would be the case if moisture were allowed to dry off the leaves without being disturbed.

HARVESTING.

For many years the handling of hoe crops, such as field beans, upon an extensive scale was impossible because of the great amount of hand labor necessary to gather the crop. Within recent years, however, labor-saving devices have been invented so that now the once laborious practice of hand-pulling individual plants can be done away with by the use of a bean harvester.

This implement is built on the principle of a pair of shears and consists of two long steel blades mounted upon a strong framework carried upon wheels, as illustrated in figure 3. The long shear-like blades are set to cut the roots of the plants just beneath the surface of the ground. Above these blades guard rods or guide rods are so arranged as to move from their original positions the plants whose roots have been severed, and, since the implement is designed to cut two rows of beans across the field, the plants of two rows are thrown together in a single windrow. This clears a space for the passage of one of the animals in the team, so that it is necessary for only one to pass through the standing crop, thus decreasing the amount of loss by shelling which would result from both animals being driven through the standing crop.

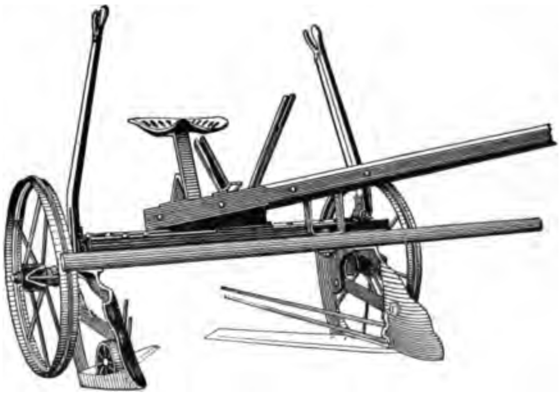


FIG. 3.—A bean harvester.

After the plants are thrown together by the harvester, as shown in figure 4, it is customary for men with ordinary pitchforks, either 2 or 3 tined, to follow the harvester and place the beans in small heaps, as shown in figure 5, to cure for several days before storing them in barns or sheds for thrashing. In some instances, where the work is done upon a very extensive scale and where the loss from shelling is not considered sufficient to justify the employment of hand labor for bunching the beans with forks, an ordinary horserake is employed for the purpose (see fig. 6).

Where the beans are to remain for a longer period and to become more thoroughly cured in the field and where the work of harvesting is done entirely by hand, the crop is frequently placed in shocks which are built about a pole 4 or 5 feet in height, both ends of which have been sharpened and one end firmly placed in the ground. A small quantity of straw, grass, or other material is placed around the base of the stake, and the beans as they are pulled are piled around the pole until a compact miniature stack about 4 or 5 feet high is formed, as shown in figure 7. This operation is very similar to the common practice followed by the growers of peanuts in stacking and curing this crop. The curing process in any case is carried far enough to prevent the vines molding after storing them in the barn prior to thrashing. If the vines are thoroughly ripened in the field before harvesting, they can be stored in from two to three days if the weather is satisfactory. If, however, the vines have some green leaves upon them and the pods are not thoroughly dry, the period for curing in the field is of necessity much longer than with thoroughly ripened plants.

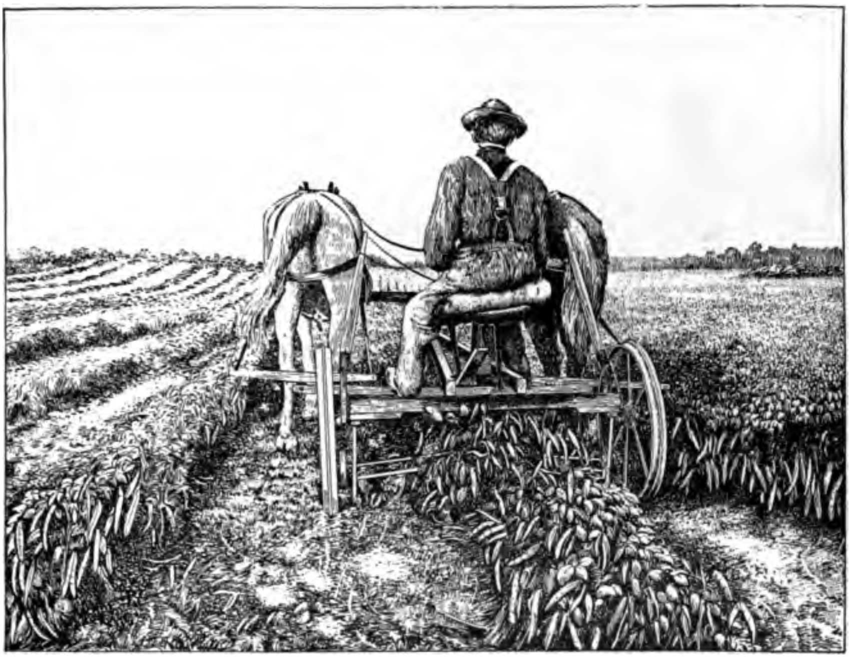


FIG. 4.—A bean harvester at work.

After the crop has been properly cured in the field it is customary to store the beans in barn lofts or in sheds until the weather has become quite cool before the work of thrashing is done. In some instances, however, if the beans are thoroughly field cured they may be thrashed in the field; but ordinarily, in those regions where beans are extensively grown, weather conditions will not permit of their being cured and left in the field a sufficient period to enable the entire work of harvesting and thrashing to be carried on in the open.

After the plants are thoroughly cured they are carried as carefully as possible to the building in which they are to be stored. In fact, all operations connected with the harvesting and field management of beans should be done as carefully as possible, in order to avoid injury to the plants while in the growing condition and to prevent shelling the beans after they have ripened. Most varieties of beans shell more or less easily after the pods have become thoroughly matured. The loss from shelling will depend largely upon the care in handling them during the various operations of harvesting and storing. Most extensive growers of beans, however, consider the loss by shelling resulting from the use of labor-saving machinery of less money value than the added cost of carrying on all operations by hand in the most careful way. In other words, the loss from the use of labor-saving machinery is not sufficient to justify the return to hand labor in the care and management of the crop.

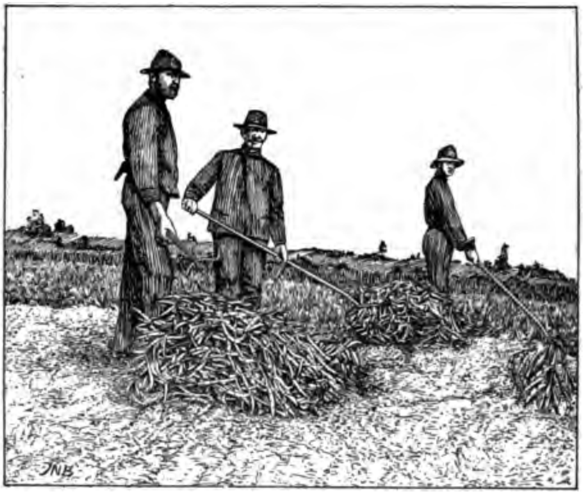


FIG. 5.—Bunching beans by hand.

THRASHING.

Because of the ease with which the pods of the bean are broken and split and the danger of breaking and splitting the seed of the bean, the operation of thrashing is one of the most exacting connected with the production of dry beans. In olden times beans were thrashed almost exclusively by the use of the flail, and small crops are still handled in this way. On an extensive scale, however, beans are thrashed by machinery specially designed for the work. The ordinary grain thrasher can not be modified so as to satisfactorily do the work, although it is sometimes employed when other specially designed machinery can not be obtained.

The modern bean thrasher, a section of which is shown in figure 8, consists in reality of a double, or tandem, thrashing machine, carrying one cylinder which is operated at a comparatively low rate of speed and a second cylinder run at a much higher speed. The slow cylinder, which is the first, separates the beans from the dry pods.

The vines, with the tougher pods, are then passed on to the second cylinder, which is operated at a much higher rate of speed and is better equipped to separate the beans from the pods which are tough and more retentive. By this arrangement there is less injury to the seed and consequently less loss both from splitting the beans and from passing over beans in tough pods, which would be the result of thrashing with a single cylinder machine operating the cylinder at a low rate of speed.

CLEANING AND GRADING.

While the farm operations in connection with the preparation of field beans for market usually cease with the thrashing of the crop, the cleaning and grading of the product is a very important item and requires much hand work. Besides the removal of sticks and straws from the grain by the use of the fan, the beans are passed through a machine which is provided with a broad, slow-moving belt placed at such an angle that split beans and peas, dirt, and stones which are not removed by the fan adhere to the belt and are thrown out, while the smooth, perfect seeds fall back into another receptacle and are thus separated from the dirt and broken seeds. After this the beans are usually subjected to a third operation, which consists in removing by hand all broken and discolored seeds, as well as foreign matter, which were not removed in the other operations. The work of hand picking is chiefly carried on by women, and is facilitated by the use of machines operated by the feet or some other

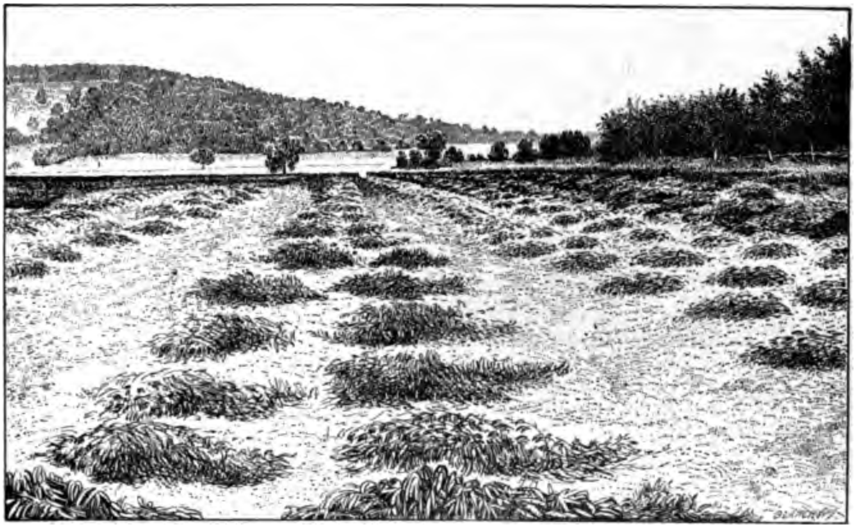


FIG. 6.—Beans bunched with a horserake.

motive power. In large picking establishments these machines are arranged in rows, fed through hoppers, and operated by steam or other power. In smaller establishments and upon farms, similarly constructed machines operated by foot power are employed.

These machines are very simple in construction, consisting of a canvas belt about 6 inches wide passing over rollers, which are operated, as already indicated, either by power or by a foot pedal. The beans which are in the hopper are shaken out upon the canvas belt, and as the belt is carried along the expert picker removes all discolored or broken seeds and foreign matter, dropping them into side receptacles having spouts which carry them into barrels or baskets, from which they can be easily removed. The good beans are allowed to fall over the end of the belt into another hopper and are conducted to a convenient receptacle.

GARDEN BEANS.

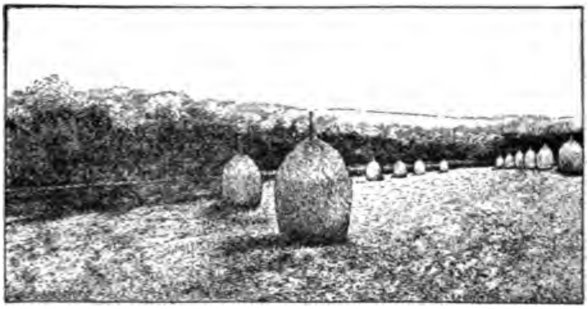


FIG. 7.—Hand-pulled beans stacked to cure.

As has been previously pointed out, garden beans naturally fall into two distinct classes, namely, bush and pole beans. Each of these general classes is again subdivided into Kidney and Lima beans. The Kidney beans of the bush type are either wax podded or green podded in character, as are also the pole beans of this class. Lima beans, as is indicated in the classification on page 8, are either of the bush or pole type. Among the garden beans, therefore, there are bush and pole types of the Kidney bean which may be either green or wax podded; and of the Lima beans there are bush and pole types. The character of the so-called Lima beans varies considerably, but chiefly in the character of the seed itself and in the habit of growth of the plant. These differences will be discussed briefly under the topic of Lima beans.

The type as well as the variety of garden bean to be grown is determined by the purpose for which it is to be used. If it is to be used as a snap or string bean for early market, quick-maturing green or wax-podded varieties are selected. If for canning purposes, a different variety is selected, which may have either green or wax pods, while as a rule green beans which are required late in the season for table use belong to the pole type. For early beans, however, the bush type is the one most commonly used.

It is to be regretted that there are no available statistics giving the acreage, yield, and value of garden beans. The map shown as figure 9 gives the geographical distribution of this industry. The range and extent of the cultivation of this crop are coincident with the business of market gardening and truck growing. Every market gardener, whether he is catering to the demand of a small town or to the requirements of a city market, grows a greater or smaller acreage of beans for use as string or snap beans. It is his purpose to plant the crop so as to secure a succession of pickings from early in the season until the plants are destroyed by frost. With the truck grower, however, the object is quite different. He depends for his profit upon growing a large acreage of a variety which sells well and which will come to marketable maturity at a time when the products of the particular zone in which he is located have the ascendancy in the market. He does not expect to anticipate this particular period or to reap a benefit after the product of another section located farther north and closer to the market than his own becomes a competitor. In the one case the crop is grown for a continuous supply over a long period; in the other, the aim is to secure a large product of desirable quality for a short time only. Figure 10 shows a typical field of beans as grown at the South for use while green.

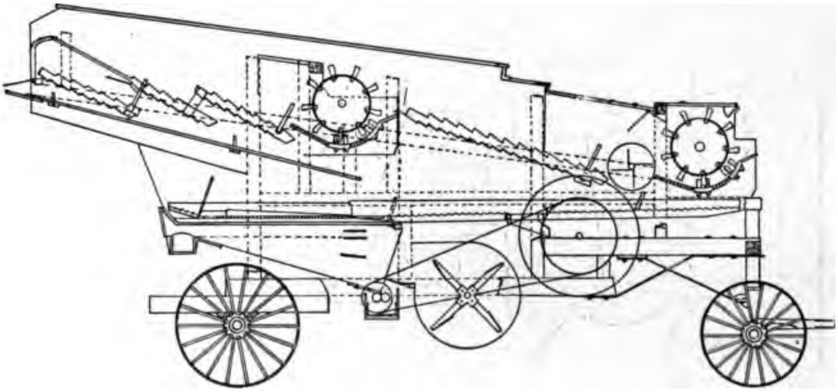


FIG. 8.—A bean thrasher.

A third factor entering into the production of beans of this type is the canning industry. String beans are a staple canning product, and while the canners, located in the cities which are large receiving and distributing points for truck crops, depend to some extent upon the purchase of these products in the open market, yet each of them attempts to have grown in the immediate vicinity of the factory a considerable acreage of each of the staple products canned by that factory. As a result of this practice, beans are grown to some extent exclusively for canning purposes, but not to the extent that tomatoes, peas, and corn are grown.

SOIL.

Beans adapt themselves to a wide diversity of soils and climate. In fact, garden beans, because they are of rapid growth and reach marketable maturity within a very short time after the seeds have been planted, can be used at certain periods of the year in localities where they can not be successfully grown as a staple field crop for dry beans. Because of this adaptation of the plant, truck growers along the Gulf and Atlantic coasts, from Texas and Florida northward, are enabled to produce a marketable crop of this vegetable by taking advantage of that portion of the season best suited to its growth. The statement just made in regard to the adaptation of this crop to various soils is emphatically brought out by studying the types of soils upon which it is successfully grown from southern Florida to Maine.

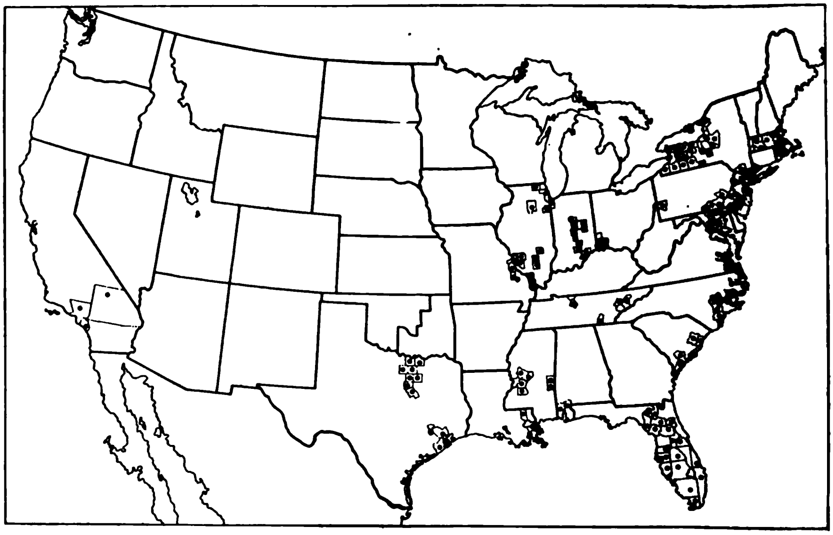


FIG. 9.—Map of the United States showing counties in which string beans are commercially grown.

The sandy soils of Florida, sandy loams of the Carolinas, Norfolk sandy loam, gravelly loams, and the clay loams of the States north of New Jersey all produce satisfactory crops of garden beans when care in the selection of varieties and in the use of fertilizers is exercised. In general it may be said that climate or season is as great a factor in determining the yield and profit from the cultivation of garden beans as is soil.

Preparation of the soil.—The bean is a hoe crop, and for that reason demands a soil free from obstructions to cultivation—one which is quick and responsive and contains an abundance of available plant food. The preparation should be such as will enable seeds to germinate quickly; that is, so fine that when the seeds are planted the soil shall come closely in contact with the seeds and insure quick germination. Mechanically the soil should be fine, retentive of moisture, and capable of being compacted, yet light enough to permit cultivation immediately after showers and rains, so that heavy crusts will not form and retard the germination and growth of the plant.

For the reception of the seed the soil should be thoroughly plowed and harrowed with an implement which shall fine and at the same time compact it. The depth to which the soil should be cultivated must be determined by experience. It is not wise to plow the land more deeply for beans than for other truck crops. As a general principle, however, soils used for market garden or truck purposes should be plowed deeply and pulverized thoroughly, so as to maintain a seed bed from 8 to 10 inches in depth.

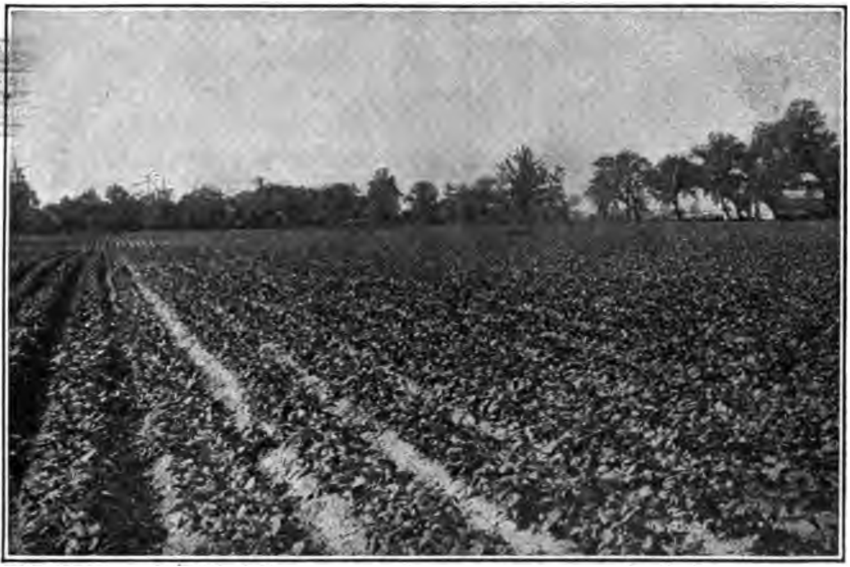


FIG. 10.—A typical field of beans grown in the South for use while green.

FERTILIZERS.

While beans are quick-growing and early-maturing plants requiring an abundance of available plant food in the soil, yet, because of their family relations, being legumes, they make the soil better for having been grown upon it. They are nitrogen-gathering plants, and for this reason require only a small percentage of this element in any fertilizer used upon them. While heavy applications of fertilizers containing nitrogen, phosphoric acid, and potash are used by truck growers in the production of beans, as a rule such fertilizers should be relatively richer in phosphoric acid and potash than in nitrogen. The production of garden beans for snap or string beans, however, demands a larger percentage of immediately available nitrogen than does the production of field beans for the dry grain, as in the former case the crop occupies the land a shorter time and therefore gives it less opportunity to provide itself with a supply of nitrogen from the atmosphere. The fertilizer, if used in the form of commercial fertilizer, may be distributed broadcast over the area occupied by the crop with a grain drill or a fertilizer distributer, or it may be scattered along the row at the time the seeds are sown by one of the many types of seed drill having a fertilizer attachment.

PLANTING.

Garden beans, like field beans, may be planted either in hills or in drills. The customary practice, however, is to plant the seeds in drills so that they shall fall 2 or 4 inches apart in rows far enough apart to admit of cultivation with either one or two horse implements. Because of their peculiar habit of germination—the elongation of the part between the root and the seed leaves, called the hypocotyl—the seed leaves or cotyledons are lifted out of the soil. A large expenditure of energy on the part of the plant is necessary to accomplish this, and the more compacted the soil and the deeper the seed is planted the more time and energy are required in accomplishing this result. It is evident, therefore, that the shallower the beans can be planted without retarding satisfactory germination, the better.

Upon thoroughly fine and compacted soils the seeds are planted from 1½ to 2 inches deep. Shallower planting does not as a rule give as satisfactory germination as planting within the range above mentioned.

While garden beans are planted in extensive areas, as is indicated by figure 9, they are, nevertheless, frequently used as a catch crop between other plants, such as squashes and cucumbers. The bean, being a quick-growing plant, matures its crop and is out of the way before the entire area is demanded by the companion crop. In addition to the value of the crop secured from the beans, it is claimed that they act beneficially as a windbreak to shelter the tender vines of the cucumber during their early life. Beans also serve to increase the income from areas upon which the most intensive types of truck farming are conducted. Upon such an area, where a fall and a spring crop of lettuce are grown, beans are planted between the lettuce plants just before they reach marketable size, so that about the time the lettuce is removed the area will be occupied by the young beans. It not infrequently happens that the catch crop will defray the expenses of growing the main crop, a matter of great importance in intensive agricultural operations.

Quantity of seed necessary.—The seed required to plant an acre of beans varies with the style of planting, 10 to 12 quarts being required where 3 or 4 seeds are placed together in hills 18 inches apart with the rows 30 inches apart, while 1 bushel to 1½ bushels are needed for scattering the seeds with 2 to 3 inches between them in drills 30 inches apart.

CULTIVATION.

After the beans have appeared above the surface of the ground, the subsequent cultivation should be carried on with implements which stir the surface of the soil only and leave it fine, loose, and almost perfectly smooth. To accomplish this with horsepower implements it is necessary that they have numerous narrow, shallow-working teeth. Cultivators with broad teeth, which tear up the earth to the depth of 4 to 6 inches, leave the ground rough, cloddy, and uneven, thus exposing a large area to the action of the sun and wind, bringing about an undue loss of moisture and indirectly acting to retard the growth of the plant, while shallow cultivation with implements having fine teeth, stirring the soil to the depth of 2½ to 3 inches and leaving the soil fine and loose, has a tendency to conserve moisture by preserving a blanket, or mulch, of loose earth over the compact water-carrying strata, in which the roots of the plants are fixed. This type of cultivation is of decided importance and value in connection with the cultivation of all quick-growing crops which require an abundant supply of moisture for their development.

As the plants become large and heavy, it is advisable at the last cultivation to use winged teeth upon the cultivator in order to throw a small quantity of soil against the stem of the plant to assist in supporting it and for the purpose of covering the root slightly more than it was normally covered by practicing level culture.

HARVESTING.

From the nature of the product the harvesting of garden beans for use as string or snap beans must necessarily be done by hand. Their extensive culture is therefore restricted to areas in which an abundant labor supply which can be commanded at short notice is available. The importance of this is suggested by the extent of the area shown in figure 10, as well as by the number of laborers shown in figure 11.

The market gardener, depending upon a limited labor supply, in a region where the wage is high, can not afford to cultivate extensive areas of string beans. The trucking district along the Atlantic coast from Georgia northward to Washington is favored by an abundance of colored labor which has, through many years, been trained in this class of work. The ample supply of this labor, while it is not highly efficient, permits the harvesting of the crop at a reasonable compensation, thus allowing extensive areas of string beans to be grown at a satisfactory profit to the planter. It is customary to harvest string beans by the measure, most growers using a bushel basket as the unit for payment.

After the beans are picked they are carried to a convenient sorting table, either in the open or under shelter, where they are looked over, all diseased and broken beans rejected, and the baskets uniformly filled and shaken down preparatory to covering them for shipment. The method of assorting beans is shown in figure 12. As is suggested by this illustration, string beans are usually shipped in bushel or half-bushel baskets of the Delaware type. These baskets are made of thin staves, have circular heads and covers, and are usually reenforced with wooden or wire hoops. A ventilated cover is also provided, which is held in place by wire fasteners. After being assorted and packed in these baskets, the beans are transported, if only a short distance, by freight or express without refrigeration; but if shipped long distances they are sometimes placed in refrigerator cars and shipped by freight.

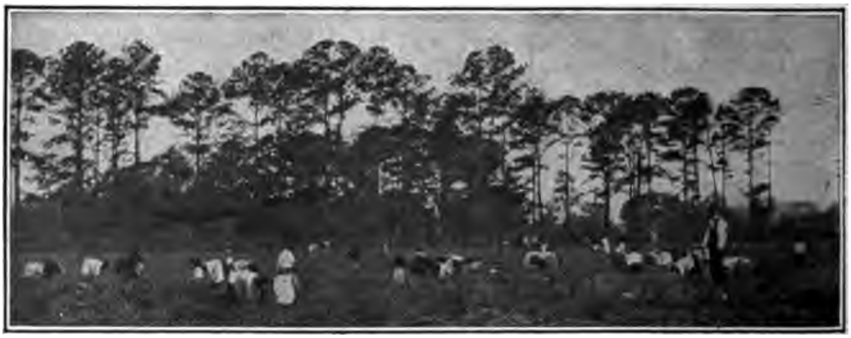


FIG. 11.—Harvesting snap beans.

When packed in baskets of this character great care should be exercised to keep the beans from becoming moist, and their storage in cars or rooms where they will heat and take up moisture should be avoided. Beans are not so liable to injury from heating as peas, but loss sometimes occurs from this cause. In the market beans are usually sold by measure rather than by weight, although the only satisfactory basis upon which to sell any garden vegetable is that of weight.

YIELD.

Under favorable circumstances the best varieties of beans yield very large quantities of pods. It is not unusual to gather 200 bushels of string beans from an acre, the price ranging from $2.50 to 50 cents per half-bushel basket from early in the season until its close for any particular locality.

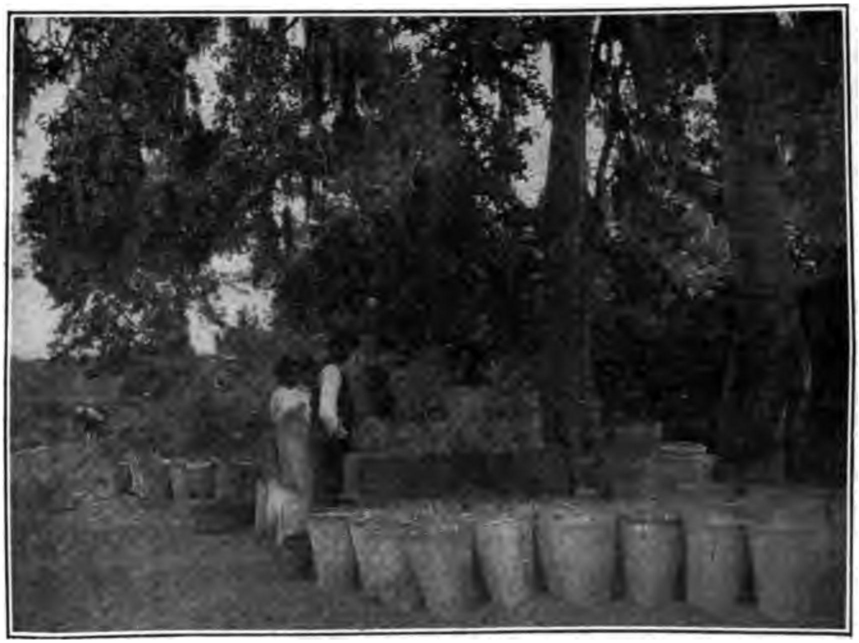


FIG. 12.—Packing and assorting beans in a truck garden.

LIMA BEANS.

Under the name of Lima beans two distinct types are now recognized: Pole Limas and dwarf, or bush, Limas. These types are made up from two distinct species, known to botanists as *Phaseolus lunatus*, which includes the Sieva, or Carolina, type of Lima beans, and *Phaseolus lunatus*, variety *macrocarpus*, the true Limas of the American garden, which includes both types of this bean, i. e., the flat, or large-seeded, Lima and the Potato Lima. The pole Lima beans, then, are made up from the Sieva, or Carolina, Limas, the true Limas, the flat, large-seeded Limas, and the Potato Limas.

The dwarf Limas are represented in the Sieva type by Henderson's Dwarf Lima, in the Potato Limas by Kumerle's and Dreer's Dwarf Lima, and in the true Limas by Burpee's Dwarf Lima. It will be seen, therefore, that botanically the pole Lima and the dwarf Lima can not be separated—that varietal differences alone make the distinctions which characterize these two groups.

Lima beans are of very great commercial value, but are not sufficiently appreciated as a table food because it is not generally known that in a dry state they can be used in practically the same manner as are the common beans. In reality they are richer and more delicate in flavor than the common beans, and can be used in as many different ways. The virtues of these types as green beans need only a passing mention, and their value as an accompaniment of corn in succotash is well known to every consumer of canned goods.

Planting.—The common method of handling the Lima bean in the climate of the northern tier of States, outside of the irrigated belt, is to plant from three to five beans in hills 18 to 36 inches apart, with the rows 3½ to 4 feet apart, and after all danger from cold and from insect enemies is past the beans are thinned to about three plants to the hill. As the beans are exceedingly tender, it is necessary to delay planting in the open until about a week or ten days after the time for planting the common garden beans. After the second cultivation, when the tendency to climb has manifested itself, the plantation is supplied with poles from 5 to 6 feet high, or with a trellis running from end to end of the row, which may be made by stretching two or three wires lengthwise of the row and weaving between them strands of ordinary wool twine. If the trellis is employed the beans can be planted in practically continuous rows, so that they stand about a foot apart. Toward the northern limit for cultivating this crop, one is fortunate if one-half to two-thirds of the pods which set upon the plants mature the seed. Farther south the crop is proportionally heavier.

In California and in other irrigated regions where there are well-marked wet and dry seasons, the dry season, accompanied by heavy fogs, occurring during the summer months, it is possible to cultivate Lima beans somewhat as follows: Upon moderately rich, somewhat sandy valley land, cultivation can be carried out by planting the beans as soon as all danger from rains has ceased and the plantation will remain dry except for irrigation. If there has not been sufficient winter rain to thoroughly moisten the land it should be well watered and allowed to dry to a good cultural condition before planting. Seed can then be planted in hills about 3½ or 4 feet apart each way, or in drills, the beans scattered about a foot apart in rows 4 feet apart. After the beans have germinated it may be necessary to cultivate them once or twice with a sweep of some type, to destroy any weeds which may have sprung up from the moist ground. All moisture should be withheld and a dust mulch over the surface preserved by running a sweep over the plantation once or twice more, and then the vines should be allowed to take possession of the territory. This obviates the necessity of using poles, and the crop can grow to maturity under these conditions without irrigation, without cultivation, and without poles.

At harvest time a root cutter is passed under the lines of the rows, severing the roots of the plants, and after the plants have dried and become somewhat cured they are thrown into convenient heaps for loading on wagons and are allowed to remain in these heaps until near the approach of the rainy season. Then they are carried to the thrashing floors, where they are beaten out by the tramping of animals or by driving over the heap a device somewhat similar to the ordinary cutaway harrow. Where Lima beans are grown very extensively, power thrashers of large capacity are used for separating the beans from the vines. There is more loss reported from the use of these machines than where the old method of tramping them out is followed, but whether this is sufficient to justify the slower process of shelling can only be determined from actual field tests.

The dwarf Lima beans, because of their habit of growth, are planted and cultivated practically the same as are field beans. They are slightly hardier than pole Limas, and for that reason toward the northern limit of the range of this crop can be planted somewhat earlier in the season than the pole Limas.

Cultivation.—The Lima bean is naturally a long-season crop, and in its native country is practically a perennial plant; hence the necessity, in a region with a limited growing season, for taking advantage of every factor in soil and climate which will tend to shorten the period of growth and hasten maturity. It is possible to lengthen the season by artificial means, when growing the plant on a limited scale, by planting the seeds in berry boxes or on inverted sods in a hotbed or cold frame two or three weeks in advance of the regular planting season. The season in the field can be shortened by withholding nitrogenous fertilizers, which tend to induce late growth; by supplying fertilizers like muriate of potash and acid phosphate, which have a tendency to hasten maturity, and by selecting what is known as a quick soil—one which dries out and warms up early in the spring and which, because it is normally inclined to be dry, has a tendency to shorten the life cycle of the plants growing in it.

DISEASES AND ENEMIES.

One of the factors which is of great moment in determining the range of cultivation of field beans is the bean weevil. This pest is much more destructive to beans grown south of the latitude of New York than in areas north of this region. The high altitudes of California and of the Allegheny Mountain region are exceptions to this general rule. Because of the greater destructiveness of the weevil in southern latitudes, dry beans for seed purposes or for table use are not extensively cultivated. As has been pointed out, this crop is confined chiefly to northern latitudes and to high altitudes. In the production of string beans, where the product is marketed in an immature condition, the weevil does not enter as a factor into the production of the crop.

The bean, like many other of our valuable economic plants, is subject to serious diseases, the most important of which is known as anthracnose. This disease is most severe upon the wax-podded types of garden beans, but few of the bush beans, whether of the wax or green pod type, are entirely free from this trouble. Localities may be comparatively free from it for a number of years, but as bean growing becomes more general and extensively engaged in, the disease becomes more prevalent and increases in severity. Growers of field beans have found that the disease is most destructive to the early planted crop, and to partially overcome the loss from its attacks have resorted to planting the crop as late in the season as possible.

While anthracnose can be controlled to a considerable extent by spraying with Bordeaux mixture, the expense of the operation, including the cost of material and of labor for applying it, is so great as to prohibit its general use in the field cultivation of the crop. In market gardens and in restricted areas, where beans are sold at very remunerative prices, it may be advantageous and profitable to treat plants for this disease. The greatest relief from this trouble, it is believed, will come from the breeding of disease-resistant strains of the desired type of bean.

FARMERS' BULLETINS.

The following is a list, by number, of the Farmers' Bulletins available for distribution. The bulletins entitled "Experiment Station Work" give in brief the results of experiments performed by the State experiment stations. Titles of other bulletins are self-explanatory. Bulletins in this list will be sent free to any address in the United States on application to your Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

22. The Feeding of Farm Animals. Pp. 40.
24. Hog Cholera and Swine Plague. Pp. 16.
27. Flax for Seed and Fiber. Pp. 16.
28. Weeds: And How to Kill Them. Pp. 30.
30. Grape Diseases on the Pacific Coast. Pp. 15.
32. Silos and Silage. Pp. 30.
33. Peach Growing for Market. Pp. 24.
34. Meats: Composition and Cooking. Pp. 31.
35. Potato Culture. Pp. 24.
36. Cotton Seed and Its Products. Pp. 16.
42. Facts About Milk. Pp. 32.
44. Commercial Fertilizers. Pp. 38.
47. Insects Affecting the Cotton Plant. Pp. 32.
48. The Manuring of Cotton. Pp. 16.
51. Standard Varieties of Chickens. Pp. 48.
52. The Sugar Beet. Pp. 48.
54. Some Common Birds. Pp. 48.
55. The Dairy Herd. Pp. 30.
56. Experiment Station Work—I. Pp. 30.
58. The Soy Bean as a Forage Crop. Pp. 24.
59. Bee Keeping. Pp. 48.
60. Methods of Curing Tobacco. Pp. 24.
61. Asparagus Culture. Pp. 40.
62. Marketing Farm Produce. Pp. 31.
63. Care of Milk on the Farm. Pp. 40.
64. Ducks and Geese. Pp. 55.
65. Experiment Station Work—II. Pp. 32.
66. Meadows and Pastures. Pp. 30.
69. Experiment Station Work—III. Pp. 32.
71. Essentials in Beef Production. Pp. 24.
72. Cattle Ranges of the Southwest. Pp. 32.
73. Experiment Station Work—IV. Pp. 32.
74. Milk as Food. Pp. 39.
77. The Liming of Soils. Pp. 24.
78. Experiment Station Work—V. Pp. 32.
79. Experiment Station Work—VI. Pp. 27.
80. The Peach Twig-Borer. Pp. 16.
81. Corn Culture in the South. Pp. 24.
82. The Culture of Tobacco. Pp. 22.
83. Tobacco Soils. Pp. 23.
84. Experiment Station Work—VII. Pp. 32.
85. Fish as Food. Pp. 32.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
91. Potato Diseases and Treatment. Pp. 15.
92. Experiment Station Work—IX. Pp. 30.
93. Sugar as Food. Pp. 31.
97. Experiment Station Work—X. Pp. 32.
98. Suggestions to Southern Farmers. Pp. 48.
99. Insect Enemies of Shade Trees. Pp. 30.
100. Hog Raising in the South. Pp. 40.
101. Millets. Pp. 30.
102. Southern Forage Plants. Pp. 48.
103. Experiment Station Work—XI. Pp. 30.
104. Notes on Frost. Pp. 31.
105. Experiment Station Work—XII. Pp. 32.
106. Breeds of Dairy Cattle. Pp. 48.
107. Experiment Station Work—XIII. Pp. 32.
108. Saltbushes. Pp. 20.
110. Rice Culture in the United States. Pp. 28.
112. Bread and Bread Making. Pp. 40.
113. The Apple and How to Grow It. Pp. 32.
114. Experiment Station Work—XIV. Pp. 28.
116. Irrigation in Fruit Growing. Pp. 48.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 30.
120. Insects Affecting Tobacco. Pp. 32.
121. Beans, Peas, and Other Legumes as Food. Pp. 38.
122. Experiment Station Work—XVI. Pp. 32.
124. Experiment Station Work—XVII. Pp. 32.
125. Protection of Food Products from Injurious Temperatures. Pp. 24.
126. Practical Suggestions for Farm Buildings. Pp. 48.
127. Important Insecticides. Pp. 46.
128. Eggs and Their Uses as Food. Pp. 40.
131. Household Tests for Detection of Oleomargarine and Renovated Butter. Pp. 10.
132. Insect Enemies of Growing Wheat. Pp. 38.
133. Experiment Station Work—XVIII. Pp. 32.
134. Tree Planting in Rural School Grounds. Pp. 32.
135. Sorghum Sirup Manufacture. Pp. 40.
137. The Angora Goat. Pp. 48.
138. Irrigation in Field and Garden. Pp. 40.
139. Emmer: A Grain for the Semiarid Regions. Pp. 16.
140. Pineapple Growing. Pp. 48.
142. Principles of Nutrition and Nutritive Value of Food. Pp. 48.
144. Experiment Station Work—XIX. Pp. 32.
145. Carbon Bisulphid as an Insecticide. Pp. 28.
147. Winter Forage Crops for the South. Pp. 40.
149. Experiment Station Work—XX. Pp. 32.
150. Clearing New Land. Pp. 24.
151. Dairying in the South. Pp. 48.
152. Scabies in Cattle. Pp. 32.
154. The Home Fruit Garden: Preparation and Care. Pp. 16.
155. How Insects Affect Health in Rural Districts. Pp. 19.
156. The Home Vineyard. Pp. 22.
157. The Propagation of Plants. Pp. 24.
158. How to Build Small Irrigation Ditches. Pp. 28.
159. Scab in Sheep. Pp. 48.
161. Practical Suggestions for Fruit Growers. Pp. 30.
162. Experiment Station Work—XXI. Pp. 32.
164. Rape as a Forage Crop. Pp. 16.
165. Silkworm Culture. Pp. 32.
166. Cheese Making on the Farm. Pp. 16.
167. Cassava. Pp. 32.
168. Pearl Millet. Pp. 16.
169. Experiment Station Work—XXII. Pp. 32.
170. Principles of Horse Feeding. Pp. 44.
172. Scale Insects and Mites on Citrus Trees. Pp. 43.
173. Primer of Forestry. Pp. 48.
174. Broom Corn. Pp. 30.
175. Home Manufacture and Use of Unfermented Grape Juice. Pp. 16.
176. Cranberry Culture. Pp. 20.
177. Squab Raising. Pp. 32.
178. Insects Injurious in Cranberry Culture. Pp. 32.
179. Horseshoeing. Pp. 30.
181. Pruning. Pp. 39.
182. Poultry as Food. Pp. 40.
183. Meat on the Farm: Butchering, Curing, and Keeping. Pp. 37.
185. Beautifying the Home Grounds. Pp. 24.
186. Experiment Station Work—XXIII. Pp. 32.
187. Drainage of Farm Lands. Pp. 38.
188. Weeds Used in Medicine. Pp. 45.
190. Experiment Station Work—XXIV. Pp. 32.
192. Barnyard Manure. Pp. 32.
193. Experiment Station Work—XXV. Pp. 32.
194. Alfalfa Seed. Pp. 14.
195. Annual Flowering Plants. Pp. 48.
196. Usefulness of the American Toad. Pp. 16.
197. Importation of Game Birds and Eggs for Propagation. Pp. 30.
198. Strawberries. Pp. 24.
199. Corn Growing. Pp. 32.
200. Turkeys. Pp. 40.

201. Cream Separator on Western Farms. Pp. 23.
202. Experiment Station Work—XXVI. Pp. 32.
203. Canned Fruits, Preserves, and Jellies. Pp. 32.
204. The Cultivation of Mushrooms. Pp. 24.
205. Pig Management. Pp. 45.
206. Milk Fever and Its Treatment. Pp. 16.
208. Varieties of Fruits Recommended for Planting. Pp. 48.
209. Controlling the Boll Weevil in Cotton Seed and at Ginneries. Pp. 32.
210. Experiment Station Work—XXVII. Pp. 32.
211. The Use of Paris Green in Controlling the Cotton Boll Weevil. Pp. 23.
213. Raspberries. Pp. 38.
215. Alfalfa Growing. Pp. 40.
217. Essential Steps in Securing an Early Crop of Cotton. Pp. 16.
218. The School Garden. Pp. 40.
219. Lessons from the Grain Rust Epidemic of 1904. Pp. 24.
220. Tomatoes. Pp. 32.
221. Fungous Diseases of the Cranberry. Pp. 16.
222. Experiment Station Work—XXVIII. Pp. 32.
223. Miscellaneous Cotton Insects in Texas. Pp. 24.
224. Canadian Field Peas. Pp. 16.
225. Experiment Station Work—XXIX. Pp. 32.
226. Relation of Coyotes to Stock Raising in the West. Pp. 24.
227. Experiment Station Work—XXX. Pp. 32.
228. Forest Planting and Farm Management. Pp. 22.
229. The Production of Good Seed Corn. Pp. 24.
231. Spraying for Cucumber and Melon Diseases. Pp. 24.
232. Okra: Its Culture and Uses. Pp. 16.
233. Experiment Station Work—XXXI. Pp. 32.
234. The Guinea Fowl. Pp. 24.
235. Preparation of Cement Concrete. Pp. 32.
236. Incubation and Incubators. Pp. 32.
237. Experiment Station Work—XXXII. Pp. 32.
238. Citrus Fruit Growing in the Gulf States. Pp. 48.
239. The Corrosion of Fence Wire. Pp. 32.
241. Butter Making on the Farm. Pp. 32.
242. An Example of Model Farming. Pp. 16.
243. Fungicides and Their Use in Preventing Diseases of Fruits. Pp. 32.
244. Experiment Station Work—XXXIII. Pp. 32.
245. Renovation of Worn-Out Soils. Pp. 16.
246. Saccharine Sorghums for Forage. Pp. 37.
248. The Lawn. Pp. 20.
249. Cereal Breakfast Foods. Pp. 36.
250. The Prevention of Wheat Smut and Loose Smut of Oats. Pp. 16.
251. Experiment Station Work—XXXIV. Pp. 32.
252. Maple Sugar and Sirup. Pp. 36.
253. The Germination of Seed Corn. Pp. 16.
254. Cucumbers. Pp. 30.
255. The Home Vegetable Garden. Pp. 47.
256. Preparation of Vegetables for the Table. Pp. 48.
257. Soil Fertility. Pp. 39.
258. Texas or Tick Fever and Its Prevention. Pp. 45.
259. Experiment Station Work—XXXV. Pp. 32.
260. Seed of Red Clover and Its Impurities. Pp. 24.
261. The Cattle Tick. Pp. 22.
262. Experiment Station Work—XXXVI. Pp. 32.
263. Practical Information for Beginners in Irrigation. Pp. 40.
264. The Brown-Tail Moth and How to Control It. Pp. 22.
266. Management of Soils to Conserve Moisture. Pp. 30.
267. Experiment Station Work—XXXVII. Pp. 32.
268. Industrial Alcohol: Sources and Manufacture. Pp. 45.
269. Industrial Alcohol: Uses and Statistics. Pp. 29.
270. Modern Conveniences for the Farm Home. Pp. 48.
271. Forage Crop Practices in Western Oregon and Western Washington. Pp. 39.
272. A Successful Hog and Seed-Corn Farm. Pp. 16.
273. Experiment Station Work—XXXVIII. Pp. 32.
274. Flax Culture. Pp. 36.
275. The Gipsy Moth and How to Control It. Pp. 22.
276. Experiment Station Work—XXXIX. Pp. 32.
277. The Use of Alcohol and Gasoline in Farm Engines. Pp. 40.
278. Leguminous Crops for Green Manuring. Pp. 27.
279. A Method of Eradicating Johnson Grass. Pp. 16.
280. A Profitable Tenant Dairy Farm. Pp. 16.
281. Experiment Station Work—XL. Pp. 32.
282. Celery. Pp. 36.
283. Spraying for Apple Diseases and the Codling Moth in the Ozarks. Pp. 42.
284. Insect and Fungous Enemies of the Grape East of the Rocky Mountains. Pp. 48.
285. The Advantage of Planting Heavy Cotton Seed. Pp. 16.
286. Comparative Value of Whole Cotton Seed and Cotton-Seed Meal in Fertilizing Cotton. Pp. 14.
287. Poultry Management. Pp. 48.
288. Nonsaccharine Sorghums. Pp. 28.
289. Beans. Pp. 28.
290. The Cotton Bollworm. Pp. 32.
291. Evaporation of Apples. Pp. 38.
292. Cost of Filling Silos. Pp. 15.
293. Use of Fruit as Food. Pp. 38.
294. Farm Practice in the Columbia Basin Uplands. Pp. 30.
295. Potatoes and Other Root Crops as Food. Pp. 45.
296. Experiment Station Work—XLI. Pp. 32.
297. Methods of Destroying Rats. Pp. 8.
298. The Food Value of Corn and Corn Products. Pp. 40.
299. Diversified Farming Under the Plantation System. Pp. 14.
300. Some Important Grasses and Forage Plants for the Gulf Coast Region. Pp. 15.
301. Home-Grown Tea. Pp. 16.
302. Sea Island Cotton: Its Culture, Improvement, and Diseases. Pp. 48.
303. Corn Harvesting Machinery. Pp. 32.
304. Growing and Curing Hops. Pp. 39.
305. Experiment Station Work—XLII. Pp. 32.
306. Dodder in Relation to Farm Seeds. Pp. 27.
307. Roselle: Its Culture and Uses. Pp. 16.
308. Game Laws for 1907. Pp. 52.
309. Experiment Station Work—XLIII. Pp. 32.
310. A Successful Alabama Diversification Farm. Pp. 24.
311. Sand-Clay and Burnt-Clay Roads. Pp. 19.
312. A Successful Southern Hay Farm. Pp. 15.
313. Harvesting and Storing Corn Pp. 29.
314. A Method of Breeding Early Cotton to Escape Boll-Weevil Damage. Pp. 28.
315. Progress in Legume Inoculation. Pp. 20.
316. Experiment Station Work—XLIV. Pp. 32.
317. Experiment Station Work—XLV. Pp. 32.
318. Cowpeas. Pp. 28.
319. Demonstration Work in Cooperation with Southern Farmers. Pp. 22.
320. Experiment Station Work—XLVI. Pp. 32.
321. The Use of the Split-Log Drag on Earth Roads. Pp. 14.
322. Milo as a Dry-Land Grain Crop. Pp. 23.
323. Clover Farming on the Sandy Jack-Pine Lands of the North. Pp. 24.
324. Sweet Potatoes. Pp. 39.
325. Small Farms in the Corn Belt. Pp. 29.
326. Building up a run-down Cotton Plantation. Pp. 22.
327. The Conservation of Natural Resources. Pp. 12.

O

Issued May 10, 1907.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 290.

THE COTTON BOLLWORM:

A Summary of its Life History and Habits, with Some Results of Investigations in 1905 and 1906.

BY

F. C. BISHOPP AND C. R. JONES,
Of the Bureau of Entomology.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

THE COTTON BOLLWORM.

INTRODUCTION.

The cotton bollworm (*Heliothis obsoleta* Fab.) is one of the most widely distributed, and most destructive of injurious Its presence has long been felt by cotton planters through South, and since about 1850 much attention has been devoted t entomologists.

The more important results of the earlier investigations con by the General Government were published in the Agricultu ports of the Patent Office for 1854 and 1855, in Comstock's Re Cotton Insects (1879), and in the Fourth Report of the United Entomological Commission (1885). More recently Bulletins 29 (old series) of the Division of Entomology were issued in 18 1893, respectively, as the result of supplementary investigatio 1896 Dr. L. O. Howard gave a very comprehensive account species in Bulletin 33, Office of Experiment Stations, which w revised and made available for general distribution as Farmers' tin 47.

Since 1903 Congress has provided for a continuous investiga the bollworm, on account of the serious injury inflicted by it western portion of the cotton belt during the past few years results of this investigation have been published in Farmers' tins 191 (1904) and 212 (1905); and in Bulletin 50 (new series) Bureau of Entomology, in which Messrs. A. L. Quaintance an Brues give a very complete and concise account of the insect to

The dissemination of knowledge resulting from the general bution of the several publications upon the life history, habi best means of control has not been entirely void of results. theless the great majority of planters have allowed its ravages tinue unchecked from year to year.

The crisis in cotton culture in Texas, brought about by the duction and spread of the well-known cotton boll weevil, has ened the planters to the importance of reducing injury by other pests, in order to better their chances of securing a fair crop of in spite of the presence of the boll weevil. Fortunately the m found to be of most value in boll weevil control and those wh being largely adopted throughout the weevil-infested area of are also of paramount importance in lessening bollworm ravag

LIFE CYCLE.

There are four distinct stages in the life cycle of the bollworm, as is the case with all butterflies and moths—namely, the egg, larva, pupa, and adult.

The egg.—The eggs of the bollworm moths are deposited upon various plants and other objects, mainly, however, on the favorite food plants of the larvæ—corn, cotton, and less frequently on tomatoes and tobacco. They are quite small (about one-fiftieth of an inch in diameter), whitish objects, and may usually be seen in numbers on fresh corn silks or scattered about on the leaves of corn or upon the foliage and fruit of cotton, though in the latter instances they are less easily seen, owing to their pale color. The accompanying figure (fig. 1) shows the peculiar sculpturing of the egg surface as seen with the aid of a magnifier.

The number of eggs laid by a single moth varies from about 300 to nearly 3,000, with an average of about 1,100.

The temperature has a decided influence upon the length of the egg stage. It varies from two and one-half days during the summer months to eight days or even longer in the spring and fall.

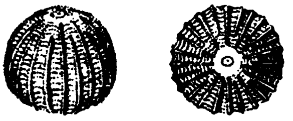


FIG. 1.—Egg of bollworm; side and top views. Highly magnified (from Quaintance and Brues).

The larva.—The larva is the destructive stage of the insect and, of course, the one most generally noticed. When first hatched it is very small and is usually overlooked until its injury to the plant upon which the egg was placed becomes severe enough to attract attention. This early period in the growth of the larva is practically the only time when it may be destroyed by the use of poisons. The period of growth of the larva is largely dependent upon temperature and the abundance of the food supply. The average length of this stage, in the summer months, is about sixteen days. During this short period the larva grows from a tiny object three-fiftieths of an inch in length to a stout worm 1¼ to 1½ inches long. There is a decided variation in the color and markings of different individuals, nearly every gradation occurring from a pale green through rose color and brown to almost black.

The pupa.—When the larva has completed its growth it leaves its food plant, usually attempting to reach the ground by crawling; it then selects a suitable spot, usually within 2 feet of the base of the plant from which it crawled or fell, and burrows from 2 to 5 inches into the soil. A cell is then constructed running back to within from one-fourth to one-half an inch of the soil surface. This provision is made so that the moth may easily push off the cap of the cell and escape. When this cell is complete the larva molts its skin at the bottom where the burrow is somewhat enlarged, and there enters the pupal or resting stage. The accompanying figure (fig. 2) illustrates the general form of a cell, with the pupa in its normal position.

As is the case with the egg and larval stages, the pupal stage is shortest during the summer months, usually lasting from twelve to sixteen days. The insect passes the winter as a pupa.

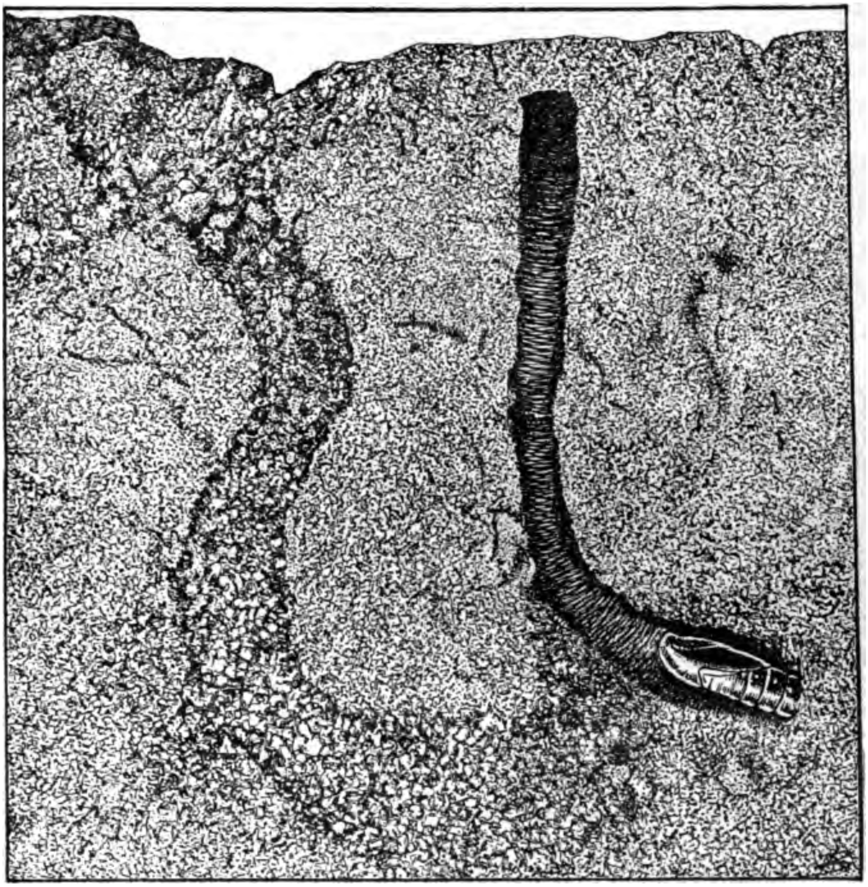


FIG. 2.—Vertical section through the soil, showing pupa of bollworm in its burrow. (Copied from Quaintance and Brues.)

The fact that the adult is unable to make its escape when the pupa is buried under a few inches of dirt and that the pupa itself is killed by undue exposure immediately suggests the importance of fall and winter plowing so as to destroy these cells and thus expose the pupæ to the inclemencies of the winter weather and to destruction by birds and other enemies. This phase of the subject will be discussed later within these pages.

The pupa is nearly four-fifths of an inch long, shining, and of a reddish brown color.

The adult.—The bollworm moth, though very readily seen in corn or cotton fields, is recognized by but few planters as the parent of the bollworm. The accompanying figure (fig. 3) may aid in its recognition.

The moths vary considerably in color and markings, ranging from a dull olive green to nearly white. Some have conspicuous markings, while with others the markings are almost entirely absent. The body is about three-quarters of an inch long, and the wing expanse is about 1⅜ inches.

During daytime the moths are seldom seen flying about, but late in the afternoon they come out from their hiding places among the foliage to seek food and deposit their eggs. It may be remarked here that the adults are capable of taking liquid food only. During the latter part of the summer this consists mainly of nectar secreted by the cotton plants. The moths are also very fond of the nectar secreted by cowpeas and when the latter are present the moths will leave the cotton fields to gather food from this source. It was found, from a large series of experiments conducted by Mr. A. A. Girault during the investigations of 1904, that the length of life of the moths depends largely upon the food supply. This also greatly influences the number of eggs deposited. In the experiments referred to above, where no food whatever was given the moths the average length of life was five and one-fourth days, and where sirup was given each day it was twenty-three and two-thirds days.

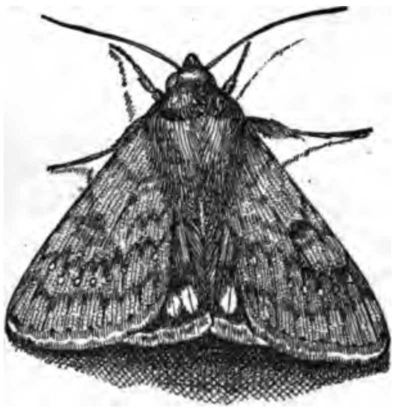


FIG. 3.—Bollworm moth in natural position, wings folded. About twice natural size (from Quaintance).

Length of life cycle.—The life cycle, from the deposition of the egg to the emergence of the moth, is completed in about thirty days during the summer months.

FOOD PLANTS.

The bollworm is practically omnivorous. Its habit of very general feeding is among the difficulties experienced in attempting its control. The plants upon which the larvæ have been known to feed number about 70. The principal crops in the United States depredated upon by this species are cotton, corn, tomatoes, tobacco, and various garden crops.

Various names have been applied to this insect according to the food plant or character of injury inflicted, the names "bud worm," "corn-ear worm," "tomato fruit-worm," etc., being variously applied. The term "sharpshooter," being very loosely used, is quite often applied to it. The exclusive use of the term "bollworm" should be encouraged to prevent confusion, regardless of the food plant upon which the insect is found.

SEASONAL HISTORY.

As has been stated, the winter is passed in the pupal stage in cells formed in the ground for that purpose. In the spring the moths emerge at a time varying considerably in different individuals and latitudes. In southern Texas, in the latitude of Victoria, the majority of the adults emerge early in April, and in northern Texas, in the latitude of Paris, about the middle of May. At Dallas, Tex., the date of the main emergence seems to be but little earlier than at Paris. Of course the time of the first as well as the maximum appearance of bollworm moths of the first generation depends largely upon the spring temperatures.

Soon after emergence in the spring the moths fly about to find suitable places for egg deposition, the great majority of them ovipositing upon the leaves of the young field corn, which is usually about 1 or 2 feet high at this time. Upon hatching, the young larvæ feed on the corn leaves, usually eating into the roll of tender leaves at the growing tip. This produces the characteristic shot-holed appearance in the leaves as they unfold.

By the time the second generation of moths appears, the corn is coming into silk and tassel and the eggs are deposited in numbers on the silks and tassels, as well as upon the leaves. This is the most destructive generation upon corn, the ears being largely attacked. The larvæ of this generation pupate about the time the ears begin to harden, so that when the moths of the third generation appear, about two weeks later, the corn ears are nearly all hard and consequently unfit for food for the young larvæ of the ensuing brood. Finding the corn hard and dry the moths are attracted to adjacent cotton fields, where most of the eggs are deposited; from these issues the destructive August generation of larvæ, which is the main source of injury to the cotton crop. Corn is by far the most preferred food of bollworms, hence if they can find late corn in the neighborhood the moths oviposit upon it rather than upon cotton.

Injury from the fourth generation is rarely serious, as the numbers of this generation are greatly reduced by parasites and unfavorable weather conditions. The larvæ of this brood are often quite numerous on alfalfa and in a few instances do serious damage to very late cotton and corn. The larvæ of this generation usually form somewhat deeper cells than those occurring earlier in the season and for the most part they pass the winter as pupæ. However, a few moths may emerge, giving rise to the larvæ found in very late corn and gardens up to the time of heavy frosts. The number of annual generations varies in the cotton belt from four to six according to the latitude.

EXTENT OF INJURY.

Severe injury to cotton is confined largely to the western portion of the cotton belt. During the past few years Texas has suffered by far the greatest loss of any State from bollworm ravages. Yet the losses due to bollworm depredations in Louisiana, Indian Territory, Oklahoma, Mississippi, and Arkansas are by no means small.

A combination of circumstances in the western portion of the cotton-growing area has resulted in theoretically almost perfect conditions for bollworm development. The great increase in the cotton acreage during the past few years has been due largely to the development of lands west of the Mississippi on account of the westward tide of immigration. Central and northern Texas have afforded a vast practically unbroken area of cotton and the people in general have looked upon cotton and corn as the only crops to be successfully grown on a large scale. Hence the valuable practice of crop rotation has been sadly neglected. Insufficient cultivation, due in part to the tenant system so generally employed upon the large plantations in Texas, and to the planting of an acreage of cotton too great for the working force, and also the continued planting of run-down seed without regard to earliness, prolificacy, or quality of staple, have each lent their unfortunate influence in increasing the seriousness of the bollworm problem.

The average annual injury by the bollworm to the cotton crop of the United States is probably in the neighborhood of $12,000,000.

INJURY, 1903-1906.

As has been pointed out, the extent of injury to cotton varies greatly from year to year. From a study of conditions during the past few years it appears that this depends mainly upon the relative earliness of the cotton crop, together with weather conditions. The amount of plowing done during the preceding fall and winter also exerts a decided influence upon the extent of injury.

During 1903 the cotton crop was exceptionally late; owing to adverse weather conditions during the preceding fall and winter practically no plowing was done; the weather conditions during the latter part of the summer were favorable for bollworm increase; as a result, a year of severe and widespread depredations was experienced. Conditions in 1904 were almost the reverse and injury was much less general and less severe. The crop was planted very early, this being due in part to the fact that weather conditions during the fall and winter of 1903 permitted general plowing and preparations for planting. The winter plowing evidently resulted in the destruction of many pupæ, so that the moths emerging in the spring, as well as subsequent broods, were greatly lessened. On account of the decided earliness of the crop a considerable number of bolls were sufficiently mature to escape injury in the presence of an abundance of young bolls and squares.

During 1905 conditions were again favorable for bollworm depredations, and quite heavy losses were experienced in many counties in Texas, Indian Territory, and Louisiana. For some unknown reason little preparation was made in the fall of 1904 for planting during the following spring. The severe weather in February, followed by a wet spring, especially in northern Texas and Louisiana, resulted in general late planting throughout that section. Many heavy rains in the early summer, especially in northeastern Texas and western Louisiana, resulted in the very poor cultivation of most crops, and the complete abandonment of many fields.

While severe bollworm injury to cotton occurred over a considerable area of Texas and Indian Territory during the season of 1906, the total loss due to the pest was not so great as that inflicted in 1905.

Contrary to usual conditions the counties of extreme northeastern Texas did not suffer severe injury. The area of greatest damage extended throughout the two northern tiers of counties of Texas, from Lamar and Delta to Clay and Jack counties, and included the southwestern portion of Chickasaw Nation and the southern part of Choctaw Nation, Indian Territory. The loss to cotton growers in this area varied from 10 to 65 per cent of the crop, and in certain late-planted tracts the destruction of the crop was so complete as to render it unprofitable to even pick over the fields.

The precipitation in this section during July and August was considerably greater than normal and this condition was undoubtedly accountable, in part at least, for the greater loss occasioned by the bollworm.

In the following table a comparison is made of the cotton crop for each of the years 1903 to 1906, inclusive, in those eight counties of Texas in which exceptionally severe bollworm injury was inflicted during the year 1906.

The annual crop is given for these eight counties, taken collectively, as also its percentage of the total crop of Texas for each year. The figures used in all cases are the number of bales ginned to December 13 of each year as given by the Census Bureau.

TABLE I.—*Comparison of the cotton crop of eight counties in Texas for the years 1903–1906.*

County.	Number of bales, 1906.	Number of bales, 1905.	Number of bales, 1904.	Number of bales, 1903.
Collin	46,902	31,085	85,128	55,995
Cooke	17,018	18,910	28,048	17,887
Denton	25,176	26,066	46,456	31,778
Fannin	57,241	35,887	81,081	40,314
Grayson	31,063	31,807	81,878	48,770
Hunt	54,186	27,359	66,658	45,458
Montague	30,568	30,069	36,270	27,370
Wise	32,304	32,320	40,181	30,014
Total for eight counties given above	294,458	233,453	465,650	297,581
Total for Texas	3,486,365	2,172,881	2,953,067	2,171,088
Percentage of Texas crop grown in eight counties given above	8.44	10.74	15.77	13.71

It is notable that the crop produced in these eight counties of Texas in 1906 constitutes but 8.44 per cent of the total crop of the State, while in 1904—a year of comparatively slight bollworm injury—the crop of this area was 15.77 per cent of the State's production. In 1903, a year of unusually heavy bollworm injury, the area under discussion produced 13.71 per cent of the crop of Texas. This comparatively large percentage may be explained by the fact that severe bollworm injury was more general during that year, and less severe in this section than in those counties in the extreme northeastern part of the State. The reduction of the total crop of Texas by the ravages of the boll weevil in 1903 also caused the percentage of the crop grown in these northern counties to appear larger, while in 1906 the crop produced in other parts of the State was exceptionally large, thus correspondingly reducing the percentage of the crop produced in this area of heavy bollworm damage.

The accompanying diagram (fig. 4) shows the approximate area of bollworm injury to cotton in Texas, Indian Territory, and Oklahoma during 1906.

MEANS OF CONTROL.

The control of the bollworm as compared with many insects presents unusual difficulties. However, as in the case of most insects, a careful study of its life history and habits has revealed certain facts which, if taken advantage of, render control quite certain.

CULTURAL METHODS.

Some planters seem to have gained the idea that when cultural methods are spoken of reference is being made to some complicated and impractical system of cotton growing. This erroneous idea has been largely dispelled by the distribution of publications upon this subject and by the demonstration work conducted by the Bureau of Entomology during the boll weevil and bollworm investigations.

The influence of unscientific methods of farming upon insect depredations has been repeatedly shown. In the case of the bollworm, as with many other insects, it has been found from experiments conducted during the past few years that much success attends the adoption of improved farm methods, such as:

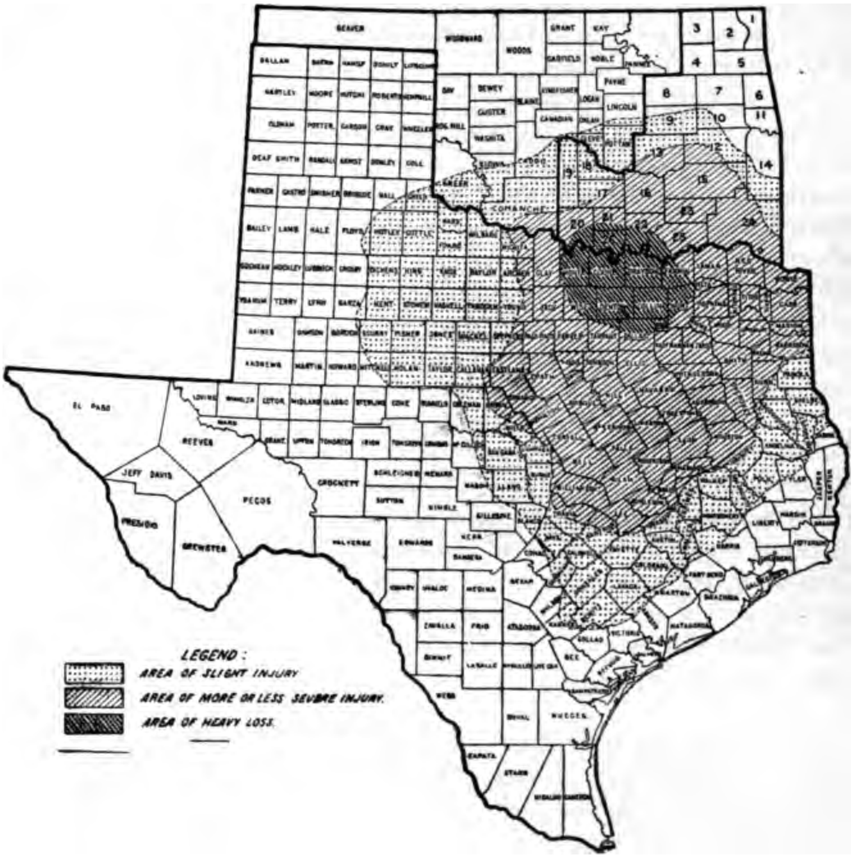


FIG. 4.—Area of bollworm injury in Texas, Indian Territory, and Oklahoma in 1906.

(1) The planting of early maturing varieties.
(2) Early planting in the spring.
(3) The use of fertilizers.
(4) Early and thorough cultivation.
(5) The plowing in the fall or winter of all land likely to contain hibernating pupæ.

In short, any farm operation which will tend to hasten fruit production and its maturity is of value. Numerous observations indicate that bolls which are three-quarters grown or more by August 1 are practically exempt from bollworm injury; in fact, it is admitted by all that early cotton is much less subjected to injury than late cotton. This is due to the preference of bollworms for the more succulent young plants and fruit. As has been stated, few bollworms attack cotton until the appearance of the third generation, about August 1; the importance of having fruit production well advanced at this date is therefore quite evident.

The planting of cotton early in the spring is practically the only operation, valuable in reducing bollworm injury, which has received general attention by planters. The advantage gained by this desirable practice is often offset, to a great extent, by the use of "rundown" seed. Oftentimes planters fully appreciate the advisability of early planting, but are unable to carry it out owing to the fact that the land has not been prepared during the fall and winter. Many delay their planting in the spring so as to be sure that all danger from frost is past. On the whole, the gains made by early planting year after year entirely eclipse the occasional losses from late frosts.

It has been amply proved that the use of fertilizers on many Texas, Louisiana, and Indian Territory soils aids greatly in securing early maturity of cotton, as well as in increasing the yield.

The allowance of ample room between the rows and the practice of early chopping so as to encourage branching close to the ground have been found valuable in increasing early square production, and the consequent early maturity of bolls. Early and frequent cultivation should also be practiced to aid in the conservation of the moisture necessary to dissolve plant food in the soil and thus hasten the growth.

In all cases the crop should be gathered as expeditiously as possible, so as to allow the land to be thoroughly plowed during the fall and winter. As has been stated, the destruction of the hibernating pupæ may be largely accomplished by this practice and, in consequence, the succeeding generations of bollworms greatly reduced. Winter preparation of the land is, of course, a requisite for early planting as well.

ARSENICAL POISONS.

In order that a thorough understanding may be had of the use of arsenical poisons against bollworms, it will be necessary to outline briefly the habits of the adults and larvæ in cotton fields.

From numerous observations made upon the egg-laying habits of the moths during the past three years it has been determined that from 60 to 78 per cent of the eggs deposited in cotton fields are placed elsewhere than on the squares and flowers.

Immediately upon hatching the young larva usually devours the eggshell from which it emerged. It then begins a restless search for food, wandering aimlessly about, and now and then eating a tiny portion of the epidermis of the plant. Often these actions are continued for hours, many of the delicate larvæ perishing before suitable food is found. The minute larvæ are unable to enter any but the most tender portions of the plant; consequently those hatching from the large percentage of eggs which are not placed on the tender squares, flowers, and small bolls crawl about and feed to a greater or less extent upon the surface of the plant until such portions are found.

A number of observations were made during August, 1905, upon larvæ hatching from eggs deposited on squares and flowers. The six larvæ under observation averaged about forty minutes in crawling about and feeding before the squares or flowers were entered—an ample time for them to have eaten sufficient poison to have destroyed them had these portions of the plant been thoroughly dusted with Paris green. Hence it appears, from various observations, that it would be theoretically possible to destroy about 90 per cent of the larvæ at the time of hatching, if the plants were kept continuously and thoroughly covered with Paris green. The impossibility of maintaining poison continuously upon all parts of the plants during the entire period of egg hatching is obvious. However, practical tests of poisoning cotton (see pp. 25–27) indicate that satisfactory results may be obtained by making from 1 to 3 applications of Paris green or other arsenical poison at the proper time.

No arbitrary date for the application of poison may be given on account of the variability of the time at which the larvæ begin to hatch in destructive numbers in different localities and seasons. Moths are seldom seen in cotton fields until the third generation appears, which is usually from July 20 to August 5. When moths in large numbers are seen flying about the fields in the evening it may be taken for granted that oviposition is taking place and the poison should be applied within three or four days.

As regards the dusting and spraying methods, the former is usually more practicable, owing to the difficulty often experienced in securing water in proximity to the fields and the greater time required in applying poison in liquid form.

The bag and pole method of application is fairly efficient and obviates the purchase of machinery. Geared machinery may be secured to apply poison either in the dust or spray form. The expense of purchasing such machinery may be reduced by two or three planters buying one machine for their common use. By the use of geared machinery from 20 to 30 acres of cotton may be dusted in the few hours suitable for the work. In order to secure good results the plants should be dusted while still wet from dew or a light shower, as the moisture aids in retaining the fine particles of poison upon the foliage.

Three pounds of Paris green should be applied per acre and where large machines are used economy may be practiced by mixing the poison with from three to four times the amount of cheap flour or fine, air-slaked lime. In spraying, the poison should be used at the rate of 1 pound to 50 gallons of water. Owing to the variability in strength of poisons only reliable brands should be purchased.

The decided prejudice on the part of many planters and pickers against the application of poison is entirely unfounded, for no danger attends its proper use either in the application or in picking cotton in fields which have been treated.

TRAP CROPS.

As has been stated, corn is the preferred food of bollworm larvæ and nectar secreted by cowpeas is very attractive to the moths. From a consideration of these facts it is perfectly natural to conclude that by proper manipulation these may be made to form a trap for the bollworm and thus protect cotton or other crops from injury.

The best results may be secured by leaving several unplanted strips, from 60 to 80 feet wide, across the fields at the time of planting cotton. These strips should later be planted to corn and cowpeas in alternate rows about 3 feet apart at a time which will permit of the corn being in silk and tassel and the peas in bloom by August 1, the approximate date of the emergence of the majority of third generation moths. The early corn being then about ripe the moths are immediately attracted to the trap rows. The cowpeas afford food and hiding places for the moths and corn is the favorite plant for oviposition; the moths are therefore content to remain in the trap rows and here their eggs are concentrated, thus leaving the adjacent cotton practically free.

The accompanying table gives some idea of the number of eggs kept from surrounding cotton fields by the employment of a small area of June corn as a trap crop. These observations were made during 1905 at Ardmore, Ind. T., on a small area of corn which was in prime silking condition on August 1. At the time of the first examination the corn was in full silk and when the second examination was made the silks were largely dry and some corn in roasting ears. The figures show the average number of eggs per plant and the average number on various portions of the plant; also the average number of larvæ per plant and their approximate sizes.

Table II.—*Average number of bollworm eggs and larvæ on corn trap crop.*

Date of examination.	Number of plants examined.	Average number of eggs per plant.					Average number of larvæ per plant.					
		On entire plant.	On leaves.	On sheath.	On tassel.	On silk.	All sizes.	Less than one-fourth grown.	One-fourth grown.	One-half grown.	Three-fourths grown.	Full grown.
August 1	10	414.3	103.6	42.2	71.7	196.8	3.4	2.7	.7	......	......	......
18	5	168	58	11	24.4	74.6	22.3	11.8	5.4	3.2	1.8	.1

Viewing the trap-crop idea superficially it might appear that the increase of bollworms would be favored by supplying their favorite food. This, however, is not the case. The concentration of the eggs upon the corn results in their destruction in large numbers by parasites and predaceous enemies which are attracted by the abundance of food and favorable breeding places furnished them in the form of bollworm eggs and larvæ. It is seldom that more than 1 or 2 of the 15 to 30 larvæ which usually hatch in the fresh silk of an ear of corn ever attain full growth on account of their cannibalistic habits.

The mistake of planting belts of corn through or around a cotton field at the usual time of planting corn in the spring is of quite common occurrence. Instead of this acting as a trap, as is desired, it is really detrimental, as the corn furnishes a favorable breeding place for the larvæ during the early summer and becomes hard about the 1st of August, thus forcing the moths of the third generation to seek other places for oviposition.

With favorable weather conditions and fair cultivation corn planted the last of May or 1st of June will be in silk and tassel by August 1. Cowpeas planted about ten days later will be in full bloom about that date. Mexican June corn is usually preferable for late planting, owing to its larger root system and consequent greater ability to withstand drought.

The trap-crop system will give best results if generally adopted by the farmers in each locality. On large plantations the planting of small areas of corn here and there in the fields is practicable. Such early crops as potatoes, oats, or wheat may be followed by corn and cowpeas with practically the same results.

The corn may be harvested in the usual way, and the peas either harvested or plowed under. Mention should be made of the benefit exerted upon the soil by the growing of cowpeas or other plants of this class.

FIELD WORK, 1905-1906.

Laboratory investigations of the bollworm, such as the breeding of parasites, the studying of predaceous insect enemies, etc., were carried on during the year 1905. Attention was devoted mainly, however, to field experiments and demonstrative work. As the investigating force was limited to the writers, it was found impossible at times, when the work was most pressing, to devote such personal attention to some of the experiments as was desired. Only a portion of the writers' time could be devoted to bollworm work during the year 1906, and for this reason laboratory investigations were entirely eliminated.

The bollworm investigations during the last three years have been confined principally to those portions of northern Texas and southern Indian Territory which have suffered most in recent years from bollworm depredations. The endeavor has been to locate the experiments, as far as possible, in territory not seriously infested with boll weevils, and thus avoid complications from this source in the results.

In general, the field work has been continued along lines similar to those followed in 1903 and 1904, some results of which were published in Farmers' Bulletins 191 and 212.

The following is a list of the experimental and demonstration farms established:

Experimental farms used in bollworm investigations.

1905.

Location.	Plantation of—	Number of acres.
New Boston, Tex.	H. B. Eubank	48
Avery, Tex.	P. B. Gibbons	40
Quinlan, Tex.	R. W. Hodge	16
Do	Joe H. Smith	24
Do	W. B. Green	8
Do	G. H. Vining	12
Do	W. F. Addington	10
Do	D. F. Borden	10
Do	W. E. Smith	10
Do	W. A. Wallace	10
Do	W. Higden	10
Greenville, Tex.	Capt. J. F. Nichols	40
Rosser, Tex.	Geo. F. Stribling	40
Ardmore, Ind. T.	W. P. Poland	20
Do	S. A. Brown	40
Atoka, Ind. T.	John Wilson	12
Mound, La.	Col. F. L. Maxwell	55

1906.

Location.	Plantation of—	Number of acres.
Denton, Tex.	S. W. Kanady	24
Mineola, Tex.	J. W. Bogan	10
New Boston, Tex.	J. N. Glass	48
Wolfe City, Tex.	C. E. Keithly	48
Do	J. C. Clement	28
Mound, La.	Col. F. L. Maxwell	55
Ardmore, Ind. T.	D. L. King	40

During 1905, in addition to the 405 acres mentioned, about 50 acres were used in 12 farms near Clarksville, Tex., in a cooperative test of the corn trap-crop system, and several small areas were used in cooperative work in other localities.

Upon these experimental farms an endeavor was made to demonstrate the value of the several remedial measures outlined in the preceding pages, under "Means of Control."

In all of the experiments conducted in 1905 the results, as shown by final yields, were supplemented by observations throughout the season upon the relative earliness of and comparative bollworm injury to the plats receiving various treatments. The results of these observations conform closely with the final yields and strongly emphasize the value of improved methods in protecting cotton from bollworm injury. These observations include cotton grown on the principal types of soil of northern Texas.

At the time of examination the injury to late planted cotton and to cotton raised from degenerate seed varied from 12 to 49 per cent, and to early planted cotton and cotton grown from improved seed the injury varied from 1 to 23 per cent.

To illustrate the decided preference of the bollworm for the less mature fruit, of a total of 24,292 squares and bolls examined in several localities, those one-half grown or less numbered 20,789, of which number 20.4 per cent were injured; the bolls over one-half grown numbered 3,504, with 7.2 per cent injured. The contrast between the percentages of injury would have been still greater had the examinations been made two weeks earlier, as a considerable number of the injured squares and bolls had fallen and were buried by cultivation, while the majority of the more mature fruit was retained by the plant even though badly injured.

ARDMORE FARM.

The experimental area on the farm of Mr. S. A. Brown was located on a typical sandy soil of the cross timber region and consisted of ten 4-acre plats.

The experiment consisted of comparing the King and Rowden varieties now becoming so generally adopted in the bollweevil and bollworm districts of Texas with the much later big-boll sorts from gin-run seed. The effect of commercial fertilizers upon the early maturity and total cotton production was also studied. Three standard commercial fertilizers were used in the experiment: (1) A complete fertilizer, showing by analysis 8 per cent available phosphoric acid, 2 per cent potash, and 2 per cent nitrogen; (2) a compound of acid phosphate and potash without nitrogen, the analysis of which showed 10 per cent available phosphoric acid and 4 per cent potash;

(3) acid phosphate alone, showing by analysis 14 per cent available phosphoric acid.

The following table shows the treatment given and the yield from the several plats, together with the increased yield from the use of fertilizers and improved seed, as compared with the yield of cotton from ordinary gin seed.

TABLE III.—*Treatment of and results from plats on bollworm experiment farm of U. S. Department of Agriculture, Ardmore, Ind. T., 1905.*

Plat No.	Variety of cotton.	Fertilizer, and quantity used per acre.	Date of planting.	Number of times cultivated.	Number of times hoed	Yield per acre in pounds of seed cotton.	Increase per acre in pounds of seed cotton as compared with Plat VII.	Value of increase with seed cotton at 33 cents per pound.	Cost of fertilizer per acre.	Net gain per acre.
I	King	C. B. G.,[a] 300 pounds.	Apr. 28	4	3	1,082.75	712.75	$23.25	$3.45	$20.07
II	Rowden	.....do	Apr. 29	4	3	1,003.75	638.75	20.91	3.45	17.46
III	King	Unfertilized	May 1	4	3	810.75	440.75	14.54	......	14.54
IV	Rowden	R. P. C.,[b] 300 pounds.	....do	4	3	837.50	467.50	15.42	3.23	12.19
V	King	.....do	May 2	4	3	834.50	464.50	15.33	3.23	12.10
VII	Big boll (variety unknown).	Unfertilized	May 3	4	3	370.00	....	....	......	......
VIII	King	R. A. P.,[c] 300 pounds.	May 4	4	3	917.00	547.00	18.05	2.85	15.20
IX	Rowden	Unfertilized	....do	4	3	430.25	60.25	1.99	......	1.99
X	.....do	R. A. P., 300 pounds.	May 5	4	3	749.75	379.75	12.53	2.85	9.68

[a] C. B. G.—A commercial cotton boll guano; analysis—available phosphoric acid, 8 per cent; potash, 2 per cent; nitrogen, 2 per cent.

[b] R. P. C.—A commercial potash compound; analysis—available phosphoric acid, 10 per cent; potash, 4 per cent.

[c] R. A. P.—A commercial phosphoric acid; analysis—available phosphoric acid, 14 per cent.

Table IV, which follows, shows the comparative earliness of fruit maturity on the several plats. The amount of seed cotton picked from each plat during each month is followed by the total amount picked from said plat to the end of that month.

TABLE IV.—*Comparative earliness of fruit maturity on plats on bollworm experiment farm of U. S. Department of Agriculture at Ardmore, Ind. T., 1905.*

Plat No.	Total pounds of seed cotton picked.								
	During August.	During September.	To September 30.	During October.	To October 31.	During November.	To November 30.	During December.	To December 31.
I	613	1,834	2,447	1,223	3,670	661	4,331	0	4,331
II	568	622	1,190	1,021	2,211	1,502	3,713	300	4,013
III	247	1,086	1,333	678	2,011	952	2,963	280	3,243
IV	0	916	916	821	1,737	1,303	3,040	310	3,350
V	565	1,358	1,923	821	2,744	274	3,018	320	3,338
VII	0	302	302	0	302	0	302	1,178	1,480
VIII	191	1,127	1,318	1,329	2,647	0	2,647	1,021	3,668
IX	0	303	303	533	836	0	836	885	1,721
X	0	786	786	655	1,441	836	2,277	722	2,999

From a study of the table several important points immediately present themselves. The decided earliness of fruit production upon the King plats is very noticeable. During August all of the King plats had opened a sufficient number of bolls to be picked over, while but one of the Rowden plats could be picked. The uniform earliness of the fertilized as compared with the unfertilized plats is also noticeable; for instance, on September 30 Plat I—King seed, fertilized—had produced 2,447 pounds seed cotton, while on the same date Plat III—King seed, unfertilized—had produced but 1,333 pounds. Comparing results from the use of the three different fertilizers, plats upon which the complete fertilizer was applied excelled both in earliness and total production. The average yield per acre in pounds of seed cotton was 1,043.25, 836, and 833.37 upon the plats fertilized with complete fertilizer, potash compound, and acid phosphate, respectively. The contrast in earliness and total yield in the case of Plat VIII, planted with unimproved seed and unfertilized, and the various other plats is so marked as to need no special mention.

NEW BOSTON FARMS.

Twelve plats of 4 acres each were used in the experiment conducted upon the plantation of Mr. H. B. Eubank during 1905. The soil upon which the experimental farm was located consists of a sandy loam, with a red clay admixture.

The exceedingly adverse weather conditions during the spring and early summer greatly handicapped the experiment, and resulted in a smaller yield than was anticipated; however, all circumstances considered, the results were very satisfactory.

The experiment consisted of a fertilizer test in which King, Rowden, and gin seed were used. The best results, both in earliness and total production, were obtained by using King seed, fertilized with 300 pounds of cotton-seed meal and 100 pounds of acid phosphate per acre. Almost as good returns were secured by using King seed fertilized with 100 pounds per acre of each of the following: Acid phosphate, German kainit, and nitrate of soda.

During the past season Mr. J. N. Glass conducted a similar experiment upon his plantation, which is located in the deep sandy land region south of New Boston. Owing to the comparative freedom from bollworm injury the cultural methods employed were not put to a severe test, hence the results as shown by the total yield from plats where fertilizers and improved seed were used and early planting and thorough cultivation were practiced can not be satisfactorily compared with the yields from unfertilized plats planted to gin seed and receiving only ordinary care. In all cases there was a ready response to the application of complete fertilizers, both in earliness and increased production.

SUMMARY REMARKS CONCERNING THE USE OF FERTILIZERS.

From three or even several years of tests with fertilizers the writers would be entirely unwarranted in making other than certain general statements regarding their use. The decided variability in the soil constituents, even upon the same character of land, and the variation in weather conditions during different seasons render specific recommendations inadvisable.

Many of the Texas soils have been found to be benefited by phosphoric acid. As the chief object of these experiments has been to increase early fruit production, and as acid phosphate influences and hastens fruiting, the general plan has been to supply an abundance of this element along with the other elements in which the various soils are supposed to be deficient.

The question is still open as to whether the general use of fertilizers upon the rich bottom lands and strong, black waxy lands of northern Texas will prove of value. However, there seems to be no doubt that the application of fertilizing elements to many of the soils of northern Texas and Indian Territory will increase the earliness and prolificacy of cotton. The experiments at Ardmore, Ind. T., and New Boston, Tex., indicate that the use of complete fertilizers with a large percentage of phosphoric acid will give best results upon the sandy loam soils of those types. Experiments conducted upon the gray or mixed soils, as in the case of the plats on the farms of Mr. C. E. Keithly at Wolfe City, Tex., and Mr. S. W. Kanady at Denton, Tex., indicate that soils of this type respond freely to the application of acid phosphate. The addition of a small percentage of potash to an acid phosphate fertilizer seems also to give beneficial results. In general, fertilizers containing large percentages of nitrogen should be avoided, as they tend to produce a large and succulent growth of stalk and foliage which favors bollworm as well as bollweevil depredations. In order to secure the best results from the use of fertilizers it is necessary that the soil be kept in good physical condition.

It is to be hoped that the data obtained during the investigations of the past three years may serve as a basis for experimentation on the part of planters in various localities to determine which of the three principal elements of plant food—namely, phosphoric acid, potash, and nitrogen—and what proportions and amounts of each, will give the best results on their respective soils.

INJURY TO FIELD CORN.

The close relation between the depredations of the bollworm upon corn and cotton has necessitated a careful study of the insect in the former as well as in the latter crop. The characteristic injury to corn has been described in the preceding pages. Although bollworm injury to cotton greatly eclipses that to corn, the loss occasioned by its presence each year in probably more than 75 per cent of the corn ears and by the additional damage resulting from ferments, molds, and rain admitted through the exit holes of the larvæ is considerable.

Injury to young corn by the first brood of bollworms is seldom serious. A notable exception, however, is presented in the case of extremely severe injury inflicted upon young corn by this brood at Victoria, Tex., during the spring of 1905. Mr. W. W. Yothers, of the Bureau of Entomology, investigated this outbreak quite thoroughly during the latter part of May. It was found that severe injury had been inflicted over quite an extended area, necessitating the replanting of a considerable portion of the corn acreage to June corn or cotton. It was estimated by Mr: Yothers and others that the total yield in the vicinity of Victoria would be reduced fully 40 per cent on account of bollworm injury. Severe injury to corn was reported also in Shackleford County, Tex., but its extent was not definitely ascertained.

In 1905 numerous observations in northern Texas and Indian Territory showed the number of eggs and larvæ to be comparatively few upon corn until about July 1. After this date, however, from 90 to 100 per cent of the corn ears were found to be infested. No serious injury to corn was reported in 1906, but observations showed that practically complete infestation of corn ears was attained during the latter part of the summer.

The chief means of reducing bollworm injury to corn is by thoroughly breaking, during the fall and winter, all land likely to contain hibernating pupæ, a procedure which the writers have stated to be an important part of the cultural system in reducing bollworm injury to cotton. The practice of having children and plow hands destroy all larvæ noticed in the buds of young corn plants is commendable.

RESULTS OF POISON EXPERIMENTS.

During 1904 poison experiments were conducted at Ladonia, Paris, and Cooper, Tex. At Ladonia and Paris the experiments were conducted directly by the writers, while at Cooper the work was carried out by Mr. N. P. Robertson, of that place. The dusting method was used exclusively. The Paris green was mixed with fine, air-slaked lime at the rate of 1 pound of Paris green to 4 pounds of lime, and the mixture applied at the rate of 15 pounds per acre. The general plan adopted in all the poison experiments was to select two areas of from 3 to 10 acres each upon which the cotton was as uniform as possible, then to apply poison to one, leaving the other as a check.

At Ladonia and Paris 24 acres were poisoned, an equal acreage being left unpoisoned as a check. A hand blower, mounted on a wagon with wheels sufficiently far apart to include between them two cotton rows, was used in these experiments, while at Cooper a geared blower was employed. Desirable results have attended the application of poison in practically every instance. The unfavorable results shown in a few cases were attributable to unevenness of stand or to a too late application of the poison.

The results of the poison experiments at Cooper are given below:

TABLE V.—*Results of experiments of the U. S. Department of Agriculture in poisoning the bollworm, at Cooper, Tex.*

On plantation of—	Number of applications.	When applied.	Area poisoned.	Area unpoisoned—check.	Yield of seed cotton from poisoned area.	Yield of seed cotton from unpoisoned area.	Gain of seed cotton per acre where poison was applied.	Value of gain at $0.0325 per pound.	Cost per acre of poison mixture.	Cost per acre of mixing and applying poison.	Net gain per acre where poison was used.
			Acres.	*Acres.*	*Lbs.*	*Lbs.*	*Lbs.*				
S. Robertson	1	Aug. 15	2½	2½	2,508	1,892	246.5	$8.00	$0.61	$0.60	$6.79
T. C. Hunter	1	Aug. 9	5¾	5¾	6,325	5,750	100.0	3.25	0.61	0.60	2.04
Fred Johnson	1	Aug. 11	5	5	3,954	3,546	81.6	2.65	0.61	0.60	1.44
N. P. Robertson	2	Aug. 12 Aug. 18	5½	5½	5,922	3,609	420.0	13.66	1.22	1.20	11.24

The above figures show a weighted net gain of $5.21 per acre upon the four poisoned areas, as compared with similar adjoining areas which were not poisoned.

The marked gain upon the plat receiving two applications was probably not due so much to its having received two applications as to the exceptionally favorable conditions attending the poisoning. The two fields showing the greatest gain per acre were smooth, so as to admit of the easy manipulation of the large machine over the entire area, while the others were more or less rough; the wind was also favorable when the former fields were treated. A slight shower preceded the second application upon the area on Mr. N. P. Robertson's farm, thus causing the poison to adhere well to the plants.

During 1905, at Quinlan, Tex., about 50 acres were used in poison experiments. In general, the results of these experiments were satisfactory. Apparently no advantage was gained by making a second application between August 17 and 20, the first having been made between August 1 and 5.

On August 24 counts were made to determine the percentage of injury to cotton on the poisoned and unpoisoned areas on the farms of Messrs. W. A. Wallace and W. Higden. Ten typical plants were chosen in each of the poisoned and unpoisoned areas, and all fruit upon the plants and ground beneath them carefully examined. On Mr. Wallace's farm the plants on the unpoisoned plat showed that over 16 per cent of the entire fruit was injured, while only 10 per cent of fruit on plants on the poisoned plat showed injury. On Mr. Higden's farm 15 per cent of the fruit of the plants on the unpoisoned plat was found to be injured, while but 9 per cent was injured on the poisoned plat.

TRAP CROP EXPERIMENTS.

In view of the fact that the greatest benefit from the use of June corn as a trap crop will come from its general planting throughout a neighborhood, an endeavor was made during the spring of 1905 to arouse general interest in the trap-crop system among the farmers in the vicinity of Clarksville, Tex. Nearly every season bollworms are more or less destructive in this locality, hence it was deemed a desirable place for a test of this kind.

Arrangements were made with each of several planters just north of Clarksville to plant from 3 to 6 acres of June corn and cowpeas. The total area thus arranged for in the experiment was about 50 acres.

Unfortunately the abnormally heavy rains during June and early July rendered cultivation of the corn impossible. In several instances the crop was entirely killed out by the excessive rains and weed growth.

There is no way of measuring the value of a trap crop in pounds of seed cotton, as it is impossible to arrange a check plat of cotton where conditions are identical without having the plats adjacent, and in this case equal protection is afforded both of the cotton areas. Although the experiment was greatly handicapped by the above-mentioned weather conditions, numerous observations during August and September showed that the adjacent cotton was being protected to a considerable extent by the deposition of a large number of bollworm eggs on the trap corn.

At Quinlan, Tex., about 30 acres were utilized in a similar experiment, with apparently good results. In some instances, in addition to the protection afforded the adjacent cotton, a large yield of corn was obtained from the trap areas.

LOCAL EXTERMINATION.

Many insects increase with amazing rapidity from the comparatively few individuals which pass the winter successfully to the countless thousands at the close of summer. The bollworm offers a good example of this, although the increase in its case is not so striking as with some other insects.

It has been estimated by Messrs. Quaintance and Brues, from observations made during 1904, that in the third generation the larvæ resulting from one female emerging the previous spring would number 21,175; or one larva of the first generation will give rise to 683 descendants in August—a sufficient number to completely ruin 78 large cotton plants. In making these calculations due allowance was made for destruction in the different stages by various natural agencies. From these figures the importance of destroying the larvæ of the early generations is very apparent.

Experiments conducted at Quinlan, Tex., and Atoka, Ind. T., during 1905 indicate that in isolated localities almost complete freedom from bollworms in cotton may be secured by destroying the larvæ of the first and second generations in all adjacent cornfields.

Various mechanical devices have been suggested for use in destroying larvæ in corn ears. The writers have given the subject some attention, but have been unable to devise any satisfactory scheme for killing the larvæ without opening the ears by hand. When mechanical devices are used the ears are often greatly damaged and in many instances the larvæ escape.

In the experiments conducted very few larvæ of the first generation were seen in the young corn, and the fields were not carefully gone over at that time; however, nearly every ear was infested by the second brood, as is shown in the accompanying table. In case of the Mineola record, ears upon which eggs were deposited were not included in the number of those infested. Had these been included with the number of infested ears, as should have been done, the infestation would have reached about 92 per cent.

TABLE VI.—*Bollworm larvæ in corn and cost of extermination.*

Locality.	Date of extermination.	Total ears examined.	Percentage of ears infested.	Total larvæ destroyed.	Cost per acre of extermination.
Quinlan, Tex	July 25, 1905	8,615	96.1	8,706	$4.40
Atoka, Ind. T	July 29, 1905	8,279	95.7	10,924	3.54
Mineola, Tex	July 20, 1906	14,748	74.4	11,039	2.90

At Quinlan the larvæ were extracted from the ears on about 3 acres of corn and at Atoka from about 2½ acres. About 7½ acres of corn were thus treated at Mineola. The stand, however, was poor, and therefore the number of ears per acre was comparatively small. In these experiments each ear was opened sufficiently at the tip to admit of the destruction of all larvæ with the fingers. The cost of the work was increased about one-third on account of the making of a complete record of the number of eggs upon the fresh silks and the number and approximate size of all larvæ.

For several reasons it is safe to say that the practice of destroying larvæ of the early generations in corn, however important, will never be generally adopted. In the first place it would be impossible to get concerted action in work of this kind, where immediate results can not be seen. The question of securing efficient labor at the time the work should be done, though difficult, would be no more so than that of finding time to go over large areas of corn. The practice of opening the corn ears might also be objectionable in some cases, as it would increase the danger of loss from decay and mildew during rainy seasons. The husks should be closed after removing the larvæ, so as to protect the ears from injury by birds.

At present it seems that the plan of extermination can only be profitably adopted in isolated localities and where the corn acreage is small as compared with the acreage of cotton thus protected.

Owing to the fact that the moths fly freely, entire protection to cotton can not be insured even though all larvæ are destroyed in adjoining cornfields—if there are such in the immediate neighborhood. However, where some barrier exists, such as timber or a large field of grain—the former especially—between neighboring cornfields and the area for which protection is being sought, there is little danger that moths will find their way in numbers to the cotton.

THE MORE IMPORTANT NATURAL FACTORS IN BOLLWORM CONTROL.

The feeding habits of the bollworm larvæ afford them much protection from various natural enemies. The mortality from these sources is therefore much greater in the egg stage than during any other period of development. Numerous parasitic and predaceous insects destroy a great many eggs and this is especially true where the eggs are concentrated upon certain plants, as in the case of corn used as a trap crop. A tiny parasite, scarcely visible to the unaided eye, is responsible for the destruction of from 20 to 80 per cent of the eggs laid upon corn, as well as a large percentage of those upon cotton. Numerous insects feed largely upon bollworm eggs and small larvæ; the larvæ of several ladybirds and small larvæ known as aphis lions are among those most beneficial in this respect.

The larger bollworm larvæ are preyed upon by several insects, among the more important of which are several species of wasps and ground beetles. The value of the common black and red wasps which so frequently build nests in trees and outhouses near cotton fields is unquestionable. At Paris, Tex., during 1905, a nest of the former species, located in an old cotton house with several cotton fields near by, was carefully observed for two hours. The nest consisted of about 800 cells, with about 280 adults present at one time. During the period of examination 168 wasps entered with food for their larvæ and for other adults. In 118 instances the food brought in was recognized as being bollworm larvæ. Probably the majority of the other 50 wasps carried bollworms, but identification was impossible, because the larvæ were so badly mangled.

Several large robber flies, so often seen in cotton fields, and a few species of spiders, have been known to capture bollworm moths. The common toad also is beneficial, for in several instances the writers and others have found numerous bollworm larvæ in its stomach.

There are published few records of birds feeding upon bollworms, yet there is every reason to believe that bollworm larvæ and adults are destroyed by many species. Domestic fowls are undoubtedly valuable in reducing the number of bollworms on cotton located near houses and barns. Several instances have come under the writers' observation in which cotton adjacent to barns where chickens, turkeys, and guineas were kept was practically free from bollworms, while at some distance out in the fields the injury was quite severe.

One of the most important checks upon bollworm increase is the cannibalistic habit of the larvæ themselves. After the larvæ have attained considerable size they are ever ready to engage in battle with their fellows whenever they chance to meet. When two larvæ are of unequal size the smaller is usually killed and devoured by its fellow, but if their size is about the same, both larvæ often die as a result of injuries inflicted upon each other. This factor is of greatest importance in corn, for if all of the larvæ hatching in the silks of an ear should attain full growth nearly every ear would be completely destroyed. The reduction in bollworm numbers in ears of corn, due mainly to this cause, is illustrated by the following figures: During August, 1905, 10 ears of corn were examined just after the silks began dying, and 198 larvæ in all stages of development were found. This gives an average of 20 larvæ per ear, most of which were small, or about 10 times the number which would ultimately reach maturity. Cannibalism is a less important factor among larvæ on cotton, as in that case the larvæ are more generally distributed over the plants and therefore meet less frequently.

A certain bacterial disease is worthy of note as an important natural factor in bollworm control. As a rule the disease develops among the larger larvæ and a larger percentage of larvæ usually die in corn ears than upon cotton; this is probably due to the fact that more moisture is present in the corn ears than in the small fruit of cotton where the larvæ feed. From 2 to 50 per cent of larvæ taken on corn and cotton and kept in the laboratory have been found to die of this disease. Examination of several thousand ears of corn during July showed that from 1 to 5 per cent of the larvæ found therein had succumbed to this disease.

RECOMMENDATIONS.

The investigations conducted by the Bureau of Entomology during the past three years show that by the general adoption of the several means of control herein described losses from the bollworm may be largely prevented, even during years of severe injury.

The fact that bollworms do not become numerous in cotton until the hardening of the early corn about August 1 is the basis for the recommendation of certain cultural methods not only advantageous in the presence of the bollworm and boll weevil, but desirable practices in cotton growing regardless of insect enemies. These methods are as follows:

(1) Thorough plowing of the land during the fall and winter. This operation is not only the means of destroying many bollworm pupæ, but is of importance from an agricultural standpoint, in exposing the soil to the actions of rain and frost, thus helping to break up its constituents and render them more readily dissolved and consequently available for plant food. Fall plowing is also a requisite for early planting.

(2) The use of early fruiting varieties of cotton.

(3) The use of fertilizers to hasten and increase fruit production.

(4) Planting the crop as early in the spring as practicable.

(5) Early and frequent chopping and cultivations.

Along with the improved farm practices above outlined, the cotton crop may be materially protected by the use of corn and cowpeas as a trap crop (as described on pages 18–19). That the greatest benefit may be derived from the use of the trap crop system it is urged that each farmer in a neighborhood plant at least a few acres of June corn and cowpeas about the 1st of June.

The use of arsenical poisons upon the cotton will be found of value in proportion to the severity of bollworm attack. Paris green is recommended at the rate of about 3 pounds per acre, applied in the dust form, either pure or diluted with lime or flour.. Application by either the bag and pole method or by geared machinery is satisfactory. The work should be done when the plants are moist with dew or after a light shower. Two applications, when not followed immediately by rains, should be sufficient; the first should be made when the eggs begin to hatch in numbers, usually between July 25 and August 5; this may be followed by a second in about one week. If rains follow the applications, these should be repeated immediately.

Destruction of the early generations of bollworm larvæ in corn seems impracticable, except in certain cases of isolated areas and where the acreage of corn is small as compared with that of cotton.

Owing to the great value of wasps in destroying bollworm larvæ throughout the season a protest should be made against the common practice of destroying their nests. Where domestic fowls are reared these should be encouraged to feed as much as possible in adjoining cotton.

For practical as well as other reasons wild birds should be protected and encouraged in their visits to cotton fields.

O

Issued May 22, 1907.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 291.

EVAPORATION OF APPLES.

BY

H. P. GOULD,
Assistant Pomologist, Bureau of Plant Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., March 28, 1907.

Sir: I have the honor to transmit herewith, and to recommend for publication as a Farmers' Bulletin, the accompanying manuscript, entitled "Evaporation of Apples," by H. P. Gould, Assistant Pomologist.

While the recent tendency in the apple industry has apparently been to centralize fruit evaporation into distinct commercial establishments having considerable capacity and requiring capital to construct and equip, there still remain large regions in which there is a considerable surplus of fruit that is unsuitable for packing and shipping in almost every crop year. In these sections and in the less accessible commercial fruit regions there is need of stimulation of effort to utilize the lower and less desirable grades of apples in such ways as will at the same time yield a fair return to the producer and remove them from competition with the better grades in the market. Encouragement of evaporating, canning, cider making, and other methods of utilization therefore appears desirable, and of these evaporating is the one that is most applicable at present to a wide range of conditions, and therefore of most importance to the average farmer.

Respectfully,
B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
- Introduction 5
- Types of evaporators 6
  - Cook-stove evaporators 7
  - Portable outdoor evaporators 7
  - Kiln evaporators 8
  - Tower evaporators 15
  - Miscellaneous types of evaporators 17
- Evaporator appliances, etc 18
  - Paring tables 18
  - Paring machines 18
  - Bleachers 19
  - Sulphur stoves 22
  - Slicing machines 22
  - Crates and trays 22
  - Racks 22
  - Heating apparatus 23
  - Fuel 25
    - Quantity of fuel required 25
- Apples suitable for evaporation 26
- Preparing the fruit for drying 27
  - Paring 27
  - Trimming 27
  - Bleaching 27
  - Slicing, quartering, etc 28
- Drying the fruit 29
  - Capacity of floor space and racks 29
  - Oiling the floors and racks 29
  - Temperature maintained 30
  - Turning the fruit 30
  - Time required for drying 31
  - When is the fruit dry? 31
  - The curing room 32
- Handling the waste 32
- Weight of evaporated apples 33
- Laws relating to evaporated fruits 33
- Handling evaporated apples 34
- Range of prices 34
- Grading 35
- Kinds of packages used 35
- Packing 36
- Storing the fruit 38

ILLUSTRATIONS.

Page.
FIG. 1. A small portable evaporator constructed of wood 7
2. Exterior of a conveniently arranged two-kiln evaporator 8
3. First-floor plan of the evaporator illustrated in figure 2, showing the position of the principal articles of equipment 9
4. Second-floor plan of the evaporator illustrated in figure 2, showing the position of the principal articles of equipment 10
5. Interior view of the evaporator illustrated in figure 2, showing the paring room and the position of the table, parers, and other conveniences 11
6. Paring shed and bleachers of a large kiln evaporator built of brick 12
7. A one-kiln evaporator, with bins for apples adjoining the paring room 13
8. First-floor plan of the evaporator illustrated in figure 7, showing the arrangement of the principal details 14
9. Section of a kiln floor, showing the method of construction 15
10. A horizontal power bleacher 21
11. A "board" of facers 36
12. A press used in packing evaporated apples 36
13. A 50-pound box of "fancy" evaporated apples with cover removed 37
14. A 50-pound box of "fancy" evaporated apples with cover and paper lace removed 37
15. A 50-pound box of "prime" whole apples 38
16. A 50-pound box of "prime" quarters 38

291

B. P. I.—277.

EVAPORATION OF APPLES.

INTRODUCTION.

The utilization of the poorer grades of fruit is frequently an important matter to the grower. That portion of a crop which is of too low grade to market in the ordinary way can often be made to pay a large part, at least, of the expense of maintaining the orchard or fruit plantation if it is converted into some other form or handled in some way other than that practiced with the better grades. In some of the apple-growing districts the evaporating industry has kept pace with the planting of orchards and has become an important factor in the utilization of the fruit which is unfit or would prove unprofitable for marketing in the fresh state. In some of the older apple-growing sections, such as western New York, the number of evaporators in use is very large, and for many years the industry has been well established. Its present state of development, however, has been a matter of gradual evolution. During its course methods have changed more or less, appliances have been perfected, and marked improvement in the construction of the evaporators themselves has been accomplished.

The data presented in the following pages have been secured in visiting a large number of evaporators where the methods, appliances, conveniences, etc., have been studied and the operators interviewed. The information relating to packing and handling the product has come largely through the courtesy of dealers in evaporated apples. Acknowledgment is gladly made of this assistance.

Many evaporators are located in villages, at railroad stations, and at other central points; a considerable number, however, are erected in close proximity to or in conjunction with apple orchards, being owned and operated by the fruit growers themselves, each plant being intended only for "working up" the fruit not otherwise marketed from a single orchard. The evaporators located in towns or villages are usually operated by men who make a business of evaporating fruit, and the apples handled in them are bought wherever they can be obtained to best advantage. These are generally of much larger capacity than the ones at the orchards, and the type of construction and the character and number of conveniences correspond.

The average weight of ripe winter apples of mixed varieties is about 50 pounds to the bushel. In evaporating them about 40 pounds of water per bushel, or approximately 5 gallons, passes off in the form of vapor. The evaporating of apples may be said, in brief, to consist of driving off as rapidly as possible, by means of artificial heat, enough of their moisture to prevent deterioration through decay or other natural processes which occur in fresh fruit and at the same time to maintain a desirable texture and flavor.

Buildings formerly used for other purposes are frequently converted into evaporators. An old dwelling house, a blacksmith shop, a cheese factory, and even a schoolhouse and a church are examples. Others are built substantially of brick or stone, thus reducing the risk from fire, which is an important consideration.

A large quantity of fruit, in the aggregate, is still dried by primitive methods. In rural communities, especially where the "home orchard" represents the extent of fruit growing, one often sees during the autumn a flat-topped rock, the roof of some low, easily accessible shed, or other flat surface on which have been spread apples, sliced or quartered, for drying in the sun. In some sections "strings" of quartered apples hanging by a doorway to dry, or behind a kitchen stove, are still familiar sights.

While much of this sun-dried fruit is intended for home use, large quantities of it are marketed, and it is also exported to some extent. This fruit is commonly referred to as "dried apples," in distinction from that handled in evaporators, which is known as "evaporated apples."

TYPES OF EVAPORATORS.[a]

Many types of evaporators are now in use, though in a general classification they may be grouped, for convenience, under a few heads. The more important of these are:

1. Cook-stove evaporators.
2. Portable outdoor evaporators.
3. Kiln evaporators.
4. Tower evaporators.
5. Miscellaneous types.

It is well to emphasize, at this point, the fact that the descriptions which follow are representative of types only and that the details of construction and arrangement admit of endless modification. For the most satisfactory results, however, in all types, thorough ventilation is essential to insure a good circulation of heated currents of air.

---

[a] The first three types of evaporators to be described are better suited to the needs of the average fruit grower than are the last two mentioned. The latter are more complicated in construction and would ordinarily be used only in cases where the extent of the business and the investment involved require more detailed information than it is possible to give in the scope of this bulletin. Certain other types of evaporators and another phase of the evaporating industry are considered in Farmers' Bulletin No. 213.

COOK-STOVE EVAPORATORS.

Some of the cook-stove evaporators are small box-like structures, usually made of sheet iron or galvanized iron, of such a size that they can be placed on top of an ordinary cook stove. They are arranged for holding a series of small trays, on which the fruit is placed after it has been prepared for drying. Various sizes are in use, from one covering only a portion of the top of a common kitchen stove and having a capacity of only a bushel or so a day, to those requiring the entire top of a stove on which to operate it.

Another style consists of a water-tight rectangular box of tin, upon the upper surface of which the fruit is spread. The heat is supplied by boiling water. with which the evaporator is filled, the temperature being maintained by placing one end of the evaporator on top of a stove. There are various other styles of this type.

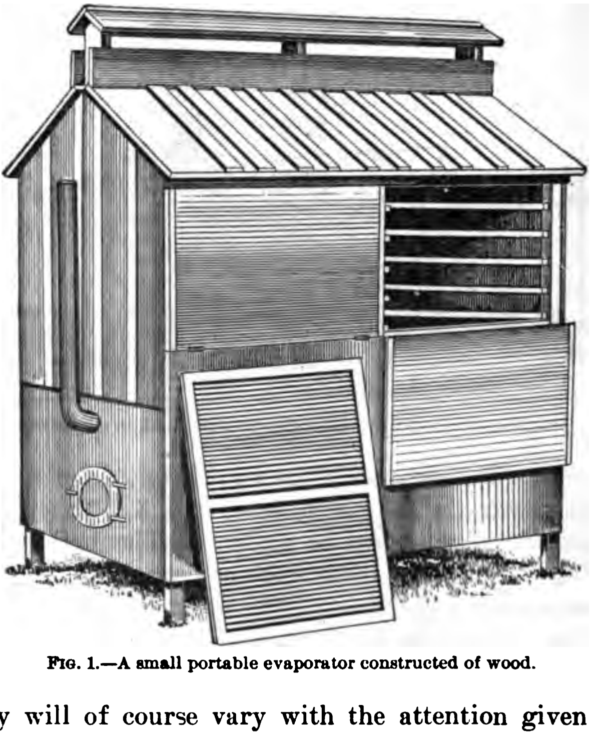


FIG. 1.—A small portable evaporator constructed of wood.

PORTABLE OUTDOOR EVAPORATORS.

Portable evaporators are especially convenient when it is desired to dry only a few bushels of fruit at any one time. The usual sizes have a capacity of 5 to 10 bushels a day, and even more in some cases, although the quantity will of course vary with the attention given to them. As they are complete in themselves and are not too heavy to be readily moved, they may be placed wherever convenience from time to time dictates.

Figure 1 shows an evaporator of this type which is constructed entirely of wood, except the parts in direct contact with the heater.

There is space for ten trays for holding fruit, similar to the one in the illustration, the dimensions of which are 2½ by 3 feet. Each tray holds about one-half bushel of fruit. Modifications of such an equipment to suit individual needs and conveniences readily suggest themselves.

There are several other styles of this type obtainable from manufacturers which are made of sheet iron, usually galvanized. As no wood enters into their construction, danger from fire is eliminated. One of these styles is provided with a heat deflector and so constructed that hot currents of air pass over the fruit as well as up through it, the claim being made that this movement of air induces a more rapid drying of the fruit than in ordinary methods of construction.

KILN EVAPORATORS.

Of the types having sufficient capacity for handling apples from large commercial orchards, the kiln evaporator is by far the most important.

While the principles of construction of the different evaporators of this type are similar in all cases, the details and the arrangement of the appliances are endlessly varied.

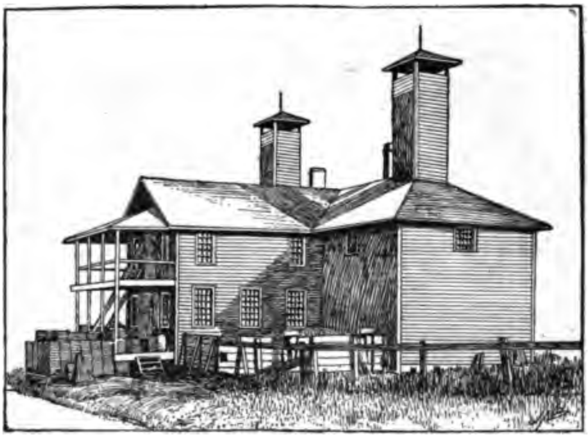


FIG. 2.—Exterior of a conveniently arranged two-kiln evaporator.

The arrangement of a very complete evaporator, from a mechanical standpoint, is shown in figures 2, 3, 4, and 5. The general features of the exterior are shown in figure 2. The building is two stories high. The floor plans suggested by figures 3 and 4 are in a measure an adaptation of the arrangement of this evaporator. The central portion of the building, which contains the floors where the fruit is prepared for drying, is 20 by 40 feet. The wings on either side, which contain the kilns where the fruit is dried, are each 20 feet square. At the front of the building shown in figure 2 can be seen an elevator by which the apples are carried to the second floor and dumped into a large bin (fig. 4, *K*). This elevator is an endless sprocket chain provided with lugs similar to the one which can be seen at the right in figure 5. The bin (fig. 4, *K*) is directly over the

the paring table (*C*) in figure 3. From this bin the apples drop down the conveyors (to be seen in fig. 5) to the paring table on the first floor. As will be observed, one of these conveyors is provided for each paring machine. At the base of each there is attached a small box into which the fruit settles, where it can be readily reached by those who operate the parers.

As the apples are pared, the peelings drop into a carrier which runs under the table, passing directly beneath the machines, and which takes them to the elevator shown in figure 5 at the right, and by this they are raised to the second floor, where they are put by hand into the bin shown in figure 4, *N*. Here they remain until they are placed on the kiln floor to dry.

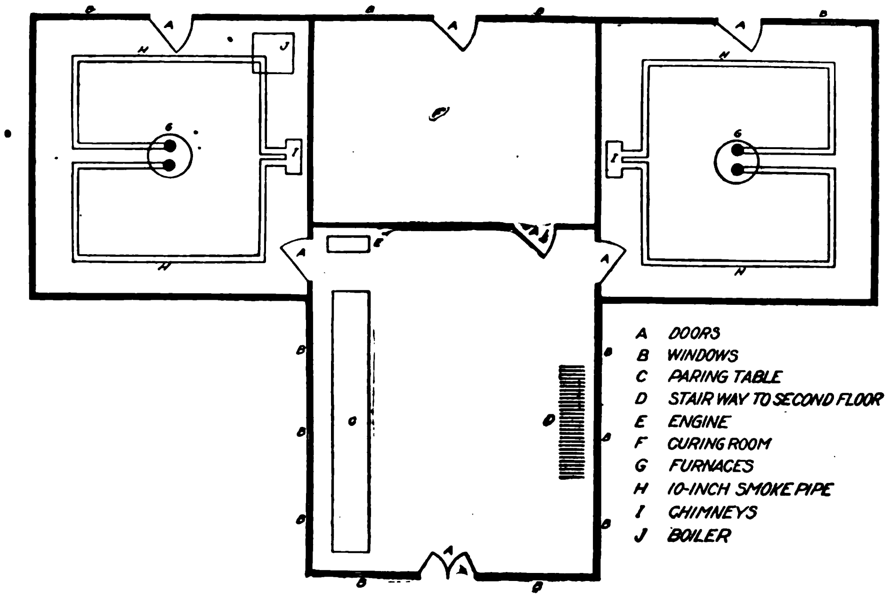


FIG. 3.—First-floor plan of the evaporator illustrated in figure 2, showing the position of the principal articles of equipment.

The pared apples drop to the paring table when they are forced off the machines. They are then trimmed (an operation to be described later), dropped into a carrier which runs in the opposite direction from the one which receives the peelings, taken to the elevator at the remote end of the paring table, by which they are raised to the bleacher (figure 4, *L*) on the second floor. They are delivered from the bleacher to the slicer, shown in figure 4, *M*, and are then spread on the kiln floors (*O*, *O*). It will thus be seen that with this arrangement the fruit passes from one operation to another with a minimum of hand labor.

Other points in the arrangement of the appliances indicated in figures 3 and 4 require notice. In the former, which shows the first floor, *D* is the stairway leading to the second floor; *E* is an engine which supplies the necessary power for running the parers, elevators, and other machinery; *F* is the room which receives the evaporated fruit when it is taken from the kilns; *G*, *G* are the furnaces which supply the heat for drying the fruit; *H*, *H* are 10-inch pipes leading from the furnaces to the chimneys at *I*, *I*; *J* is the boiler supplying steam for the engine (*E*).

In the diagram of the second floor (figure 4) the only points which require further notice are small doors *P*, *P* in the walls, which communicate with the curing room (*F*) on the first floor, and through which the fruit is passed when removed from the kilns.

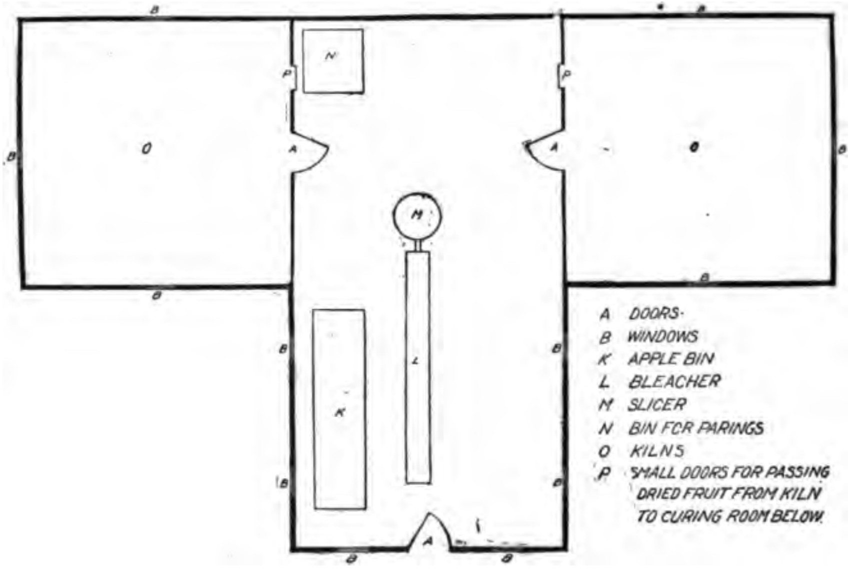


FIG. 4.—Second-floor plan of the evaporator illustrated in figure 2, showing the position of the principal articles of equipment.

This evaporator is located in Wayne County, N. Y. It was built about 1903. It is a frame building very thoroughly constructed and completely equipped. The approximate cost of the plant, the capacity of which is about 300 bushels for ten hours, with the kilns drying continuously, as stated by one of the owners, was as follows:

Building	$1,800.00
2 furnaces	150.00
5 parers	60.00
1 20-foot horizontal bleacher	75.00
1 slicer	37.50
1 chopper	$8.00
Engine, boiler, shafting, pulleys, belting, etc	450.00
Installing machinery	100.00
Total	2,680.50

A convenient arrangement for an evaporator having four or five kilns is shown in figure 6. In this one the kilns are built of brick, and the apples are pared in an adjacent building. Referring to the illustration, the portion built of slats at the left is the compartment for containing the apples in bulk. This bin extends the entire length of the building, except a small space in the center where a 5-horsepower gasoline engine is located which furnishes power for running the parers, slicers, and other machinery. The paring table[a] is on the opposite side of the building, as will be noted, from which the fruit is taken by a carrier, similar to those already described, and elevated to a platform which is on the same level as the two bleachers, which are to be seen between the evaporator and the paring shed just mentioned. This carrier discharges the fruit into trays, which are then placed by hand in one of the bleachers; from this they are taken to the slicer, located in a compartment just within the brick portion of the structure and with which all the kilns communicate, thus making it convenient to distribute the fruit after it has been sliced.

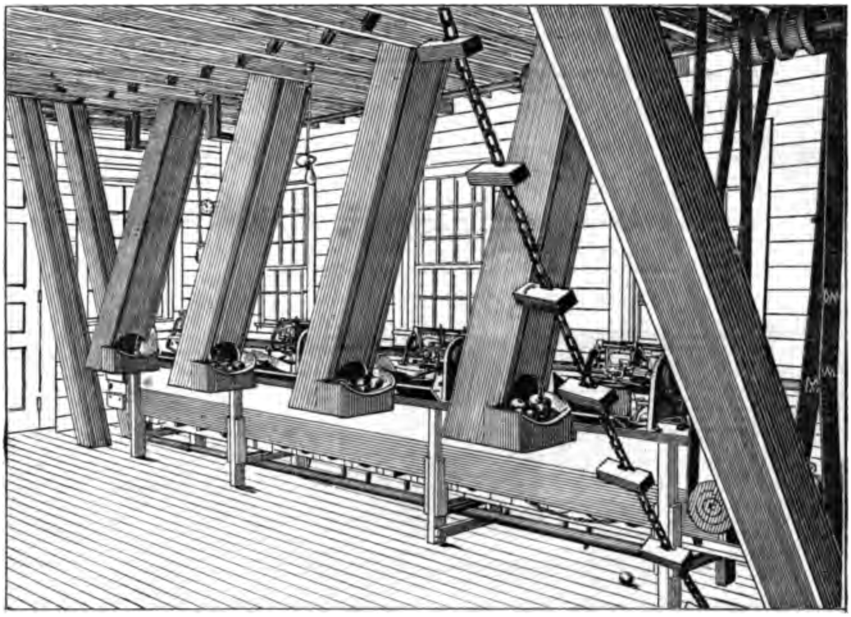


FIG. 5.—Interior view of the evaporator illustrated in figure 2, showing the paring room and the position of the table, parers, and other conveniences.

Other large establishments have the kilns arranged in a series situated end to end. The fruit is pared on the first floor of an adjoining structure centrally located; then elevated to the second floor, which is on the same level as the kiln floors, where it is bleached and sliced. Communication is had with the kilns not adjacent to the floor on which the fruit is sliced, by means of a platform extending from this floor along the sides of the kilns and on the same level as the kiln floors.

---

[a] At the time the photograph from which this illustration was made was taken this evaporator was not in operation. The parers were covered with boxes, which are seen where the machines would otherwise appear.

Of the smaller evaporators, operated entirely by hand, of which there are relatively a great number, a similar arrangement on a correspondingly limited scale will be found convenient. Where buildings which were erected for other purposes are remodeled for this use it may often be necessary to forego some of the conveniences which could be included in a building erected primarily for the evaporation of fruit.

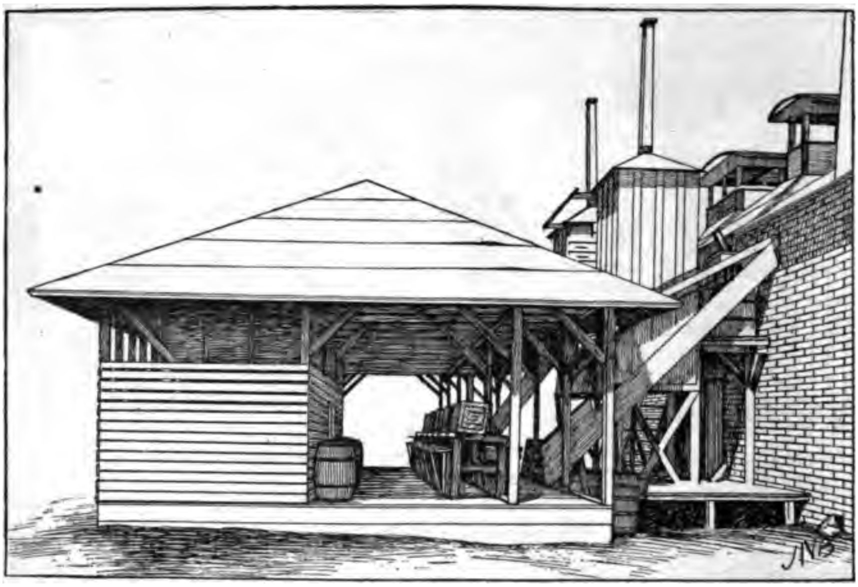


FIG. 6.—Paring shed and bleachers of a large kiln evaporator built of brick.

A conveniently arranged one-kiln evaporator is shown in figure 7. The plan of the first floor is suggested by figure 8. The space is divided into a furnace room about 14 by 16 feet and a workroom, which is somewhat smaller, in which the apples are pared. An upright bleacher, which also serves as an elevator for raising the fruit to the second floor, is placed in this room. The second floor is divided in a similar way. The kiln has the same dimensions as the furnace room, with a capacity of 75 to 100 bushels of fruit (before paring) at each filling. The workroom on this floor contains the slicer and the upper portion of the bleacher. The dried fruit, as it is taken from the kiln, can also be held here temporarily if desired.

The evaporator shown in figures 7 and 8 is constructed entirely of wood and was built in 1896 at a cost of about $300, including material and labor. It is located in western New York. At the present prices of lumber the cost would be considerably greater. A builder who could secure the lumber from his own timber tract would be able to greatly reduce the actual cash outlay. According to a statement of the owner the cost of equipment was as follows:

1 furnace	$47
2 parers	16
1 slicer	15
1 chopper	8
Ropes and pulleys for bleacher and elevator	3
Total cost of equipment	89

Such a building as the one described may readily be so constructed that it will be useful for many other purposes during the course of a year than that for which it is primarily intended.

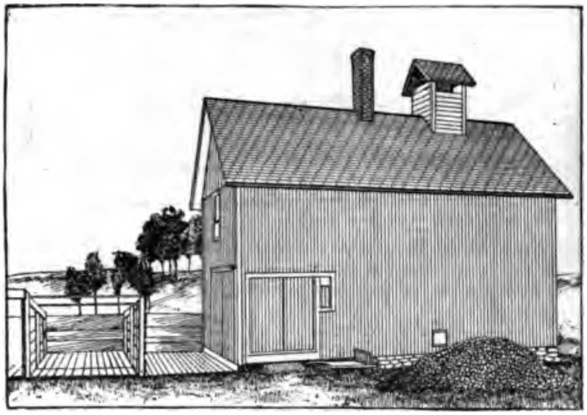


FIG. 7.—A one-kiln evaporator, with bins for apples adjoining the paring room.

In constructing kilns the same general principles are followed, whether the evaporator is a small one with only a single kiln or an extensive establishment having several of them. The most satisfactory size of kiln, all things considered, is about 20 feet square. This is a convenient size to fill, so far as the preparation of the fruit is concerned; the heat can be well regulated, made sufficiently intense for the purpose desired, and evenly distributed, so that the fruit will dry uniformly, and for various minor reasons a kiln of this size is a desirable " unit " in the construction of evaporators of this type.

A kiln consists essentially of a floor made of slats and placed over a furnace room or over a system of steam pipes. The floor is usually built from 10 to 12 feet above the floor of the furnace room. Provision should be made for regulating the heat by means of small openings at the base of the walls, communicating with the outside, which can be opened or closed as desired. The inflow of cold air can thus be regulated. Such control is especially desirable in windy weather. While many evaporators are constructed without special provision of this kind, it is an important point to have such openings, particularly if the walls are brick or otherwise made very tight, so that there is but little circulation of air.

If the evaporator is a frame building, the walls of the furnace room may well be plastered or covered with asbestos paper to lessen the danger of fire, which may otherwise be great, because of the intense heat generated within them.

If the walls, at least the portion below the kiln floor, are double, with an air space between the two sides, the insulation will be more perfect than if they are solid or of only a single thickness, thus best conserving the heat and increasing the efficiency of the plant. The height of the walls of the kiln above the drying floor should be sufficient to permit an attendant to work on the floor conveniently and with comfort.

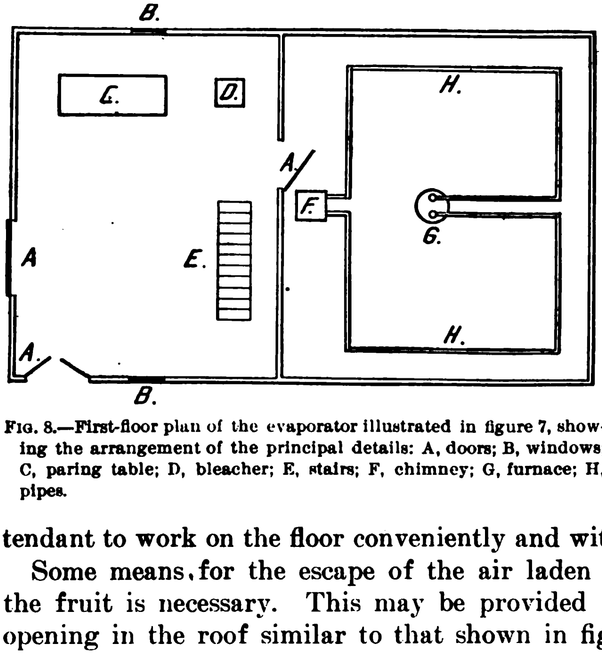


FIG. 8.—First-floor plan of the evaporator illustrated in figure 7, showing the arrangement of the principal details: A, doors; B, windows; C, paring table; D, bleacher; E, stairs; F, chimney; G, furnace; H, pipes.

Some means for the escape of the air laden with moisture from the fruit is necessary. This may be provided for by means of an opening in the roof similar to that shown in figure 1, page 7; or a cupola-like ventilator may be built, the sides of which should consist of slats placed so that they overlap one another as in an ordinary window blind. Another form of ventilator is shown in figure 2, page 8. This is in the form of a tower about 3 feet square and extending 8 or 10 feet above the roof, which is sufficiently high to cause more or less draft, and hence augments the circulation of hot air through the fruit.

The kiln floor is constructed of strips especially designed for the purpose. Such floors are generally made of poplar or basswood strips, seven-eighths of an inch thick, 1 inch wide on the top surface and one-half inch wide on the under side. In laying the floor, these strips are placed one-eighth to one-fourth inch apart on the upper surface. This makes the space between them wider on the under side than on the upper, thus allowing the small particles of fruit which work down between them to drop through without clogging the intervening spaces. Reference to figure 9 will make plain the method of constructing the floor.

The heating apparatus, parers, slicers, bleachers, details of arrangement, etc., referred to here are described under their respective headings.

TOWER EVAPORATORS.

At one time tower evaporators were extensively used in some sections for apples, but in recent years this type has been largely superseded by the kiln evaporator, so that at the present time there are comparatively few towers in use.

As the name of this type implies, a tower is its characteristic feature of construction. It may be likened to an immense chimney, provided with the necessary appliances for receiving the fruit, except that the heat alone is allowed to pass through it, a separate flue being provided for the smoke.

There is no more definitely prescribed manner in which these towers are constructed and arranged than there is governing the construction of kiln evaporators. They may consist of one tower or several. If several. they may be entirely disconnected from one another. They may be built side by side or back to back, opening on the opposite sides. They may be entirely within the building, extending through the several floors from basement to roof and projecting above, or entirely on the exterior, opening into the interior after the manner of an " outside chimney," common in some sections of the country. They may be built either of wood or brick. They are usually from 4 to 5 feet square, inside measure, and 30 or 35 feet in height, as desired. Heat is supplied by a furnace at the bottom of the tower.

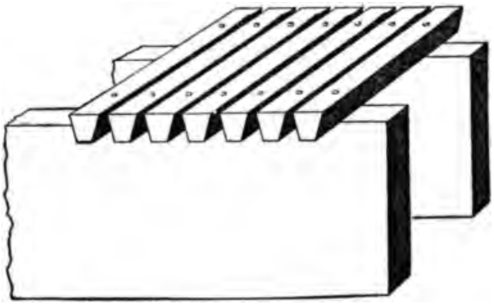


FIG. 9.—Section of a kiln floor, showing the method of construction.

There are two principal methods of constructing the towers in regard to receiving and handling the fruit to be dried. The apparatus in one case consists of two endless sprocket chains operating over wheels properly adjusted at the top and bottom of the tower. Each sprocket chain is provided with swinging brackets, corresponding with one another on each chain, for holding the racks on which the fruit is placed for drying. In one specific make of apparatus these brackets are arranged in series of six each, so that this number of racks can be put in, one immediately above another. A space of 2 feet or so intervenes on the sprocket chains between each series of six brackets. This sprocket-wheel-and-chain device for carrying the fruit in the tower is turned by means of a crank, which works on the outside of the tower.

The racks on which the fruit is dried consist of frames 4 feet long and 21½ inches wide, over which is placed galvanized-wire netting having a quarter-inch mesh. This size of rack permits the apparatus on which the racks are carried in the tower to work readily, those on one side passing upward, while those on the other side move downward, without interfering with one another.

In this method the point of admitting the fruit to the tower is near the base on the first floor. When the fruit is dry it is removed at the same point.

In operating the tower, the apparatus is turned every few minutes to bring each rack of fruit in its course to the base of the tower, where the heat is greatest. In this way it is made to dry uniformly, and each rack is brought repeatedly into view of the one in charge; hence he is always able to know its exact condition.

In one particular evaporator of this kind there are three towers, about 30 feet high, each holding 120 racks. The capacity of a single tower is about 100 bushels a day. The fruit is prepared in every detail the same as for drying in kilns.

In the other method the racks are about 4 feet square and occupy the entire cross section of the tower instead of half the space, as in the method just described. The racks are admitted to the tower at the same point as in the other style, but as each rack is put in position it is raised by a lever attachment, together with the other racks which may have been already put in place, and held in the new position by dogs or clutches which work automatically, allowing the racks to be moved upward, but not permitting them to move downward. The distance which the racks are raised each time the lever is moved is sufficient to allow another rack to be inserted below them at the usual point of admission. It will thus be seen that the racks are gradually raised from the point of insertion on the first floor to the point on the second floor where they are removed. The racks do not come into the view of the operator from the time they are inserted until they reach the place where they are removed, and so do not come under the same scrutiny of the operator as in the other style. The arrangement of the furnaces is the same in both methods of construction.

MISCELLANEOUS TYPES OF EVAPORATORS.

While the types of evaporators previously described admit of endless modification in the details of construction, and other types and styles of lesser importance are frequently seen, there is but one additional evaporator to which it seems desirable to refer in this connection. The type in question has no particular designating term applied to it. Several styles which possess some features similar to this one have been called "cabinet evaporators,"[a] and this term is applicable in the present instance. While it appears to be largely of local reputation, it is believed to possess certain points of merit worthy of more extended application in constructing evaporators of considerable capacity. The fruit is dried on racks similar to those used in tower evaporators.

In the first one of this type to be erected, so far as the writer has been able to learn, and which is still in use, the compartments in which the fruit is dried are located in the central part of a large room in which the fruit is sliced and handled after it is removed from the evaporator. Each compartment, of which there are three, is slightly more than 8 feet square, or large enough in cross section to receive four racks (two square) on the same plane. The two opposite faces or sides of these compartments are a series of narrow doors, about 6 inches wide and slightly more than 4 feet long, which extend horizontally. These doors are hinged on the lower side and held in place by a button at the top. The sides of the interior are supplied with cleats on which the racks rest. Two racks placed one directly on the other are admitted at each door. In the particular case in question, there is sufficient space between the floor and ceiling of the room for eleven of these doors, each door admitting, as stated, two racks. It will thus be seen that the capacity of each compartment is 88 racks.

As arranged in this evaporator, the racks are admitted to the drying compartments on the same side of the room that the apples are sliced, the ones that are put in first being pushed to the opposite side of the compartment, thus making room for the second set of racks in the course. The attendant in charge of the drying makes his examinations and removes the fruit when dry through the doors on the opposite side of the compartment.

It will thus be seen that the method of handling the fruit is similar to that employed in the case of the tower driers, but the work is all done on a single floor of the evaporator.

The heat is supplied by a system of steam pipes which extend in horizontal tiers through the compartments between the racks.

---

[a] See Farmers' Bulletin No. 213, "Raspberries," p. 25.

EVAPORATOR APPLIANCES, ETC.

During the development of the industry, the machinery and other appliances used in the process of evaporating apples have undergone great changes, until at the present time a high degree of perfection has been attained. Reference to some of the more important articles for equipping an evaporator may be of value to those who are unfamiliar with them. Nearly all of them may be obtained from manufacturers ready for use, hence detailed descriptions are unnecessary in most cases.

PARING TABLES.

Paring tables hardly require special reference in the present connection, but brief descriptions of a number that are conveniently arranged may be suggestive. There are two general plans of construction. One consists of a single long table common to all the machines; the other, individual tables, one for each parer.

Where several hand parers are used they are commonly placed on opposite sides of a relatively wide table, through the center of which, between the two rows of parers, is a sluice 10 or 12 inches wide and as many inches deep. An endless belt the width of the sluice covers its bottom. This belt works on rollers and is operated by means of a crank at the outer end. As the apples are trimmed they are thrown into this sluice, and the helper who attends to the bleacher fills the crates or trays in which the fruit is handled by turning the crank which moves the belt forward, carrying with it the fruit which has been placed thereon. By this means all the trimmers contribute to the filling of a single tray, thus making it possible to get all the fruit into the bleacher in the shortest possible time after it is pared. This is considered essential in order to make the highest grade product. Such a table as this is especially adapted to small evaporators which are run entirely by hand power.

In power evaporators a long table common to all the parers similar to the one in figure 5, page 11, is generally used. The necessary carriers for removing the apples and the parings operate beneath the table. If individual tables are used in such cases, a small sluice may connect each table with a carrier which works just beneath the floor, which carrier in turn delivers to an elevator that connects with the bleacher. By thus placing below the floor the carrier which takes the fruit from the tables, the space above is left unobstructed, which would not be the case were the individual tables connected with a common carrier.

PARING MACHINES.

Paring machines are made for operating either by hand or power. The more recent patterns have two, or even three, forks for holding the apples while they are being pared. The attendant puts an apple on one of the forks while one on another fork is being peeled.

The number of bushels which can be pared in a given time of course varies with the size and condition of the fruit, but 70 or 75 bushels for a day of ten hours (or even more if the fruit is of good size and the machine is speeded up to its limit) is not an unusual amount for a good power machine.

The hand machines are equally complete and satisfactory in their working. Under favorable conditions an experienced operator will pare 60 or more bushels a day if the fruit is not too small.

BLEACHERS.

In order to make the fruit as white as possible, it is usually subjected to the fumes of burning sulphur. The apparatus in which the fumes are applied is called a bleacher.

The form and manner of construction vary greatly, as do most of the other appliances. The requisites are a perfectly tight compartment having a capacity commensurate with the size of the evaporator and the necessary facilities for burning the sulphur.

Perhaps the simplest form of construction consists of a box sufficiently long to meet the requirements, placed horizontally, and large enough in cross section to admit the boxes or crates in which the fruit is handled. Rollers are placed in the bottom, on which the crates rest, which permit them to be moved along with but little friction. The crates are entered at one end of the bleacher, those previously put in being pushed along to make room for the following ones. The sulphur is usually burned immediately below the point where the fruit is put into the bleacher. A short piece of stovepipe is placed at the opposite end for the escape of the fumes after they have passed through the bleacher.

Another simple bleacher in which the fruit is handled in bulk (not in crates) consists essentially of a large square box, the interior of which is fitted with a series of inclined planes sloping in opposite directions to prevent the fruit from dropping to the bottom in a compact mass. The fruit is usually admitted at the top directly from the paring table. It then rolls from one inclined plane to another to the bottom, where there is the necessary opening, with means for closing it tightly to prevent the escape of the sulphur fumes, for removing the fruit when it is bleached. The sulphur is burned beneath the lowest inclined plane.

The bleachers shown in figure 6, page 12, are compartments 4 or 5 feet square and 5 or 6 feet high. The two bleachers, which can be seen in the illustration, face toward the platform, which extends between them. The sides of the interior are provided with series of cleats for supporting the trays in which the fruit is handled. The distance between the cleats is slightly more than the depth of the trays. The sides toward the platform consist of series of closely fitting doors about 6 inches wide, placed horizontally, through which the trays are entered and removed from the bleachers. The trays of fruit are put into the bleachers and left in the sulphur fumes a sufficiently long time for the fruit to bleach. The sulphur is burned at the bottom of the bleachers, and the tall shafts which are to be seen projecting from the top are ventilators, which give sufficient draft to take the fumes up through the fruit and to allow their escape at a point some distance above the workmen.

While all of these types may do the work well, they are so constructed that much handling and lifting of the fruit is necessary.

There is an upright style in common use in some sections, which reduces the lifting of the fruit by hand to a minimum and serves not only as a bleacher, but also as an elevator. This is especially suited to the smaller, two-story evaporators, operated without mechanical power, in which the slicing is done on the second floor and having the kiln floor on the same level. By this means the fruit is raised from the first or paring-room floor to the level of the kiln floor while it is being bleached.

The construction is comparatively simple. It consists of an upright box extending from the first floor to 3 or 4 feet or any convenient height above the second. The cross dimensions are such as to admit the crates or trays in which the fruit is handled. The crates are admitted to the bleacher at a convenient height, 18 inches or 2 feet from the bottom, through a trapdoor or some other arrangement which can be tightly closed to prevent the escape of the sulphur fumes.

A movable frame, slightly smaller than the cross dimensions of the bleacher, rests on a solid support just below the point where the crates are entered and on which the crates are placed when pushed inside. This frame is connected with a lever at the top of the bleacher by means of iron rods which are attached to a cross arm on the lever and extend down the sides of the bleacher to the frame. The relative length of the long and short arms of the lever must be such that in the sweep of the long arm the frame on which the crates rest will be raised a distance slightly greater than the depth of the crates in which the fruit is handled. There are dogs, or catches, on the inside of the bleacher, which work automatically and permit the crates to be moved upward, but not downward. When a crate is put in place, the lever is pulled down, usually by means of a rope which passes through the second floor within convenient reach of the helper who handles the crates. The crate which was last put into the bleacher and all that may have been put in previously are raised to the point where they are caught by the clutches just mentioned and so held in that position. On releasing the lever, it regains its former position and the frame drops to its place just below the level of the doorway through which the crates are admitted and is then ready for receiving another crate. A small-sized stovepipe or other tubing should extend from the top of the bleacher to the exterior of the building to permit the escape of the sulphur fumes after they have passed through the fruit.

The crates are removed through a tightly closing door in the bleacher on the second floor, where the apples are sliced and spread on the kiln floor.

The sulphur is burned at the bottom of the bleacher, below the point where the fruit is admitted. It is a safe provision to have this portion of the bleacher coated with cement or lined with asbestos, especially the floor, to lessen the danger of fire.

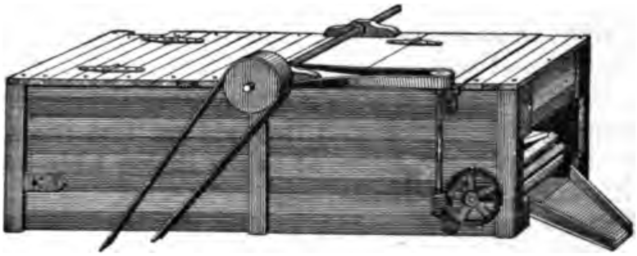


FIG. 10.—A horizontal power bleacher.

Perhaps the most satisfactory bleacher for evaporators in which an engine is installed is the "power" or "horizontal" type shown in figure 10. Its characteristic feature is the movable bottom, or rather false bottom, on which the fruit is carried through the bleacher.

Briefly stated, this bleacher consists of a tight box about 3 feet square and 20 or more feet long, the length being regulated by the capacity of the evaporator in connection with which it is operated and the time it is desired to bleach the fruit.

The apples are conveyed from the paring room to the bleacher by a carrier, or elevator, similar to those already referred to, and are dropped into one end of the bleacher, falling on the movable bottom, which consists of an endless belt of "lugs," turned by the proper gear attachment. The speed of movement is governed by the gearing, and is adjusted to correspond with the time it is desired to keep the fruit in the bleacher and the length of the latter. When the fruit has been carried through the bleacher, it passes to the slicer, which is located in close proximity to the bleacher. The end of the bleacher shown in the illustration is closed when in actual operation by means of a closely fitted piece of canvas or other effective arrangement. Provision for the escape of the fumes may be supplied as suggested in connection with the upright type previously described.

SULPHUR STOVES.

In a large proportion of instances nothing more elaborate than a broken or otherwise discarded iron kettle or some similar receptacle is used for containing the burning sulphur. This is the case if the compartment in which the sulphur is burned is a portion of, or in direct communication with the bleacher. In other instances, such as the power bleacher just described, where in some cases it is more convenient to burn sulphur at some distance from the bleacher, a small sheet-iron stove about a foot square and 12 or 15 inches high is used. This is connected with the bleacher by means of a small stovepipe.

SLICING MACHINES.

There are several styles of slicers now obtainable which are operated by hand, foot, or mechanical power. In general, they consist of a table in which a series of knives is so arranged that when the apples are carried over them by a revolving arm they are cut into slices. In at least one type the apples are delivered to the slicing table by an attachment which works automatically.

The capacity of slicers varies somewhat, as does the industry of the men who operate them, but from 200 to 400 bushels for a day of ten hours may be expected of a good machine.

Small hand slicers which slice only a single apple at a time are sometimes used in the smaller evaporators.

Quartering machines are used instead of slicers, if it is desired to dry the fruit in quarters instead of slices.

CRATES AND TRAYS.

Crates and trays are essential accessories. A relatively large supply facilitates the handling of the fruit both before and after it is pared, especially where there are no elevators or carriers to convey the fruit from one point in the evaporator to another. They are usually made to hold about a bushel. The bottoms of those in which apples are bleached should be made of narrow slats, and preferably also the sides, to permit a free circulation of the sulphur fumes through the fruit.

RACKS.

In the construction of all racks on which fruit is dried, whether for use in a large tower evaporator or in a small cook-stove type, a special caution should be observed to select only the best grades of galvanized-wire netting for making the racks. If poorer grades are used the acids of the fruit are likely to act on the metals, producing undesirable results.

HEATING APPARATUS.

Satisfactory results are so dependent upon the heating apparatus that this becomes one of the most important features of an evaporator.

In the smaller types of evaporators, where comparatively little is involved and the question of fuel does not enter seriously into consideration, almost any small stove commensurate with the size of the particular evaporator in question may be used.

In the larger kiln evaporators the matter is a more important one. Formerly, ordinary cast-iron stoves were used considerably, two or more of them frequently being required to heat a single kiln, but these have largely gone out of use. In their stead large furnaces are now most commonly used. These are specially designed for the purpose and are provided with relatively large fire pots, correspondingly large ash pits, and large radiating surfaces. As it is necessary to burn a relatively large quantity of fuel in a given time, the size of the grate is made with this end in view. For a kiln floor 20 feet square, or 400 square feet of surface, the grate surface is usually about 3 feet in diameter, containing from 5 to 7 square feet.

As to the most satisfactory length of pipe connecting the furnace and chimney, opinions differ. Perhaps the most common method of piping is the one indicated by figure 3, *H*, *H*, page 9. The furnace, with two flanges for attaching the pipe, is placed in the center; the pipe from each flange is then extended to the side of the room opposite the chimney, and from this point the two sections, extending in opposite directions, follow the wall, at a distance of 2 or 3 feet from it, to the chimney. In a kiln 20 feet square, some 65 or 70 feet are thus required. Ten-inch pipe is a common size to use for this purpose. It is placed about 3 feet below the kiln floor.

Some operators think that a better distribution of heat is obtained if the pipes extend back and forth, 2 or 3 feet apart, under the entire floor of the kiln, thus requiring 200 feet or more instead of the shorter length above suggested. The greater length, however, is less frequently used than the smaller.

In some cases the heat is so intense directly over the furnace that the fruit dries more rapidly in the center of the floor than about the sides. To regulate this and make the drying as uniform as possible, a "deflector," consisting of a piece of sheet iron or tin several feet square, is attached to the floor directly above the furnace.

Open grates, which in effect are furnaces with all parts above the grates removed, are used occasionally and are recommended by some because they require less fuel, less attention to firing, and will dry the fruit in a shorter space of time. On the other hand, so much dust rises from them that they are not used in making the best grades of fruit.

Tower evaporators may be heated by the same style of furnaces that are used in kiln driers. The size of furnace sufficient to evaporate a given quantity of fruit in a given time is probably about the same in either type of evaporator.

In some respects a steam system is the most satisfactory method of heating, but it is comparatively little used, possibly due to the larger first cost of installing such a system. It is especially applicable in case of evaporators that are operated in connection with some other business that requires the use of considerable steam power, such as a large cider mill which requires the power for running the presses.

In kiln evaporators the steam pipes are generally placed in as close proximity to the floor of the drying room as is convenient—within a foot or even closer. That every steam pipe nearest the floor may supply the greatest amount of heat it should have its own return to the main return of the system.

One-inch pipe is generally used for such systems. No very definite data are available in regard to the amount necessary to supply the requisite heat. Several kilns, however, which are said to work admirably, have about 650 running feet of pipe for every 100 square feet of floor space. One-half of this is "riser," the other half "return."

In the type of evaporator described on page 17, the length of 1-inch steam pipe required per square foot of surface directly exposed to the pipes is considerably less than in the case of the kiln just described, although it is probable that in the system in question a greater degree of heat can be maintained than with the usual piping for a kiln. As previously mentioned, in this system the pipes are arranged in horizontal tiers, the racks on which the fruit is placed being inserted between them. Hence, the upper racks receive more or less heat from the lower tiers, as well as from those to which they are directly exposed. In one evaporator of this type, which gives excellent satisfaction, and in which the drying compartments are about 9 feet square—that is, large enough to hold four 4-foot racks (two square) in the same plane—there are thirty-two 1-inch pipes in each tier. Each pipe is about 8½ feet in length, or approximately 270 feet in each tier. In the evaporator referred to there are 8 tiers in each compartment. Eight racks—two deep—are placed between each tier of pipes.

In another evaporator of this type, having a capacity of 400 bushels every twenty-four hours, a 40-horsepower boiler, with about

15 square feet of grate surface, furnishes the necessary steam when run at a pressure of 40 to 50 pounds. This is sufficient for drying the fruit and for running the parers, slicers, elevators, etc., required to handle this quantity of fruit. The steam pressure at which such systems are run varies considerably according to the individual requirements of the systems. A range of from 40 to 90 pounds has been noted in different evaporators.

FUEL.

Where the owner of an evaporator has an abundant supply of wood and it can be cut at times of leisure, this is probably the least expensive fuel in actual cash outlay that can be had in most of the apple-growing sections. In fact, under these conditions, it is commonly estimated that the fuel costs nothing. But in a great number of cases fuel has to be bought, even by operators who are drying apples from their own orchards.

For kiln evaporators using the common type of furnaces, hard coal is probably the most satisfactory fuel, and requires less attention than any other. Coke is sometimes used, and if it were as satisfactory as coal, other things being equal, it would be the cheaper fuel. But it requires much attention, and even with the best of care it is difficult to maintain a uniform degree of heat. A combination of coal and coke is sometimes used with satisfactory results, in which case the faults and advantages of one tend, in a measure, to equalize those of the other.

In a steam-heated plant soft coal serves the purpose in a satisfactory way, and in most apple-growing sections is probably cheaper than any other fuel that is readily available.

Quantity of fuel required.—While the amount of fuel necessary to dry a given quantity of fruit will vary more or less, depending upon the conditions of the weather, the efficiency of the furnace, the construction of the kiln, the percentage of moisture to be left in the fruit, and various other things, it is roughly estimated that a ton of hard coal, for a kiln evaporator, will make a ton of dried fruit. Probably the average requirement is rather more than this. It is claimed that a tower evaporator requires slightly less for the same results. Open grates also considerably reduce the amount of fuel necessary for a given quantity of fruit, but on account of their objectional features they can not be used for the better grades of apples. Coke is rather more efficient, 2,600 to 2,700 pounds of apples being evaporated, it is claimed, by a ton of fuel.

A good steam system should require considerably less than a ton of soft coal to a ton of dried fruit, one estimate being about one-half this amount.

These estimates are for evaporating sliced fruit. If the apples are quartered or dried whole, being merely pared and cored, considerably more fuel is required. From 25 to 50 per cent more fuel should probably be estimated for in such cases.

APPLES SUITABLE FOR EVAPORATION.

There is an increasing demand for dried apples of the highest quality. The tendency has sometimes been to make quantity at the expense of quality. But prices are governed not only by the supply but also by the grade. The cleanest, whitest fruit, that is well cored, trimmed, bleached, ringed, and dried, is most in demand. Carelessness in any particular injures the product.

Primarily the economic usefulness of an apple evaporator is through its utilization of windfalls and the poorer grades of fruit which can not be marketed to good advantage in a fresh state, and it is these grades that are most often evaporated. But the magnitude of the crop also influences the grade of the evaporated product in a decided way. In seasons of abundant crops and low prices for fresh fruit large quantities of apples that would ordinarily be barreled are evaporated and the grade of stock produced is correspondingly improved. On the other hand, in years of scanty crops, when all apples that can possibly be shipped are in demand at high prices, only the very poorest fruit is evaporated, as a rule, thus lowering the grade of the output.

The commercial grading of evaporated apples is based primarily on appearance rather than on dessert quality, and the fact that one variety may make a better flavored product than another is not considered. As a rule, a product of high commercial grade can be made from any sort which has a firm texture and bleaches to a satisfactory degree of whiteness. A variety of high dessert quality, such as the Northern Spy, may be expected to make an evaporated product of correspondingly high flavor.

In sections where the Baldwin apple is grown extensively it is in demand at the commercial evaporators, as it meets the requirements in a fair degree and it is also available in relatively large quantities. In the Ben Davis sections that variety supplies a similar demand.

Most early varieties lack sufficient firmness of texture for the best results and are undesirable on this account. On the other hand, some comparatively early sorts, such as Gravenstein and Yellow Summer Pearmain, are considerably prized in some sections; the dessert quality of the latter is especially high.

Similarly the product made from other sorts possesses qualities that are due more or less to varietal characteristics. For instance, that from Esopus is said to be unusually white; Hubbardston and varieties of the Russet group also make very white stock. The latter make relatively a large amount of stock, by weight, to a given quantity of fresh fruit. Limbertwig is said to produce from 1½ to 2 pounds a bushel more of dried stock than most sorts do, but it is not as white as that from some other varieties.

PREPARING THE FRUIT FOR DRYING.

PARING.

No special comments are necessary under the head of paring, save to mention this step in the order in which it occurs in the preparation of the apples for drying. The apples are cored in the same operation by an attachment applied to the paring machine for this purpose. The fruit is automatically forced from the fork and drops to the table, where it is next taken in hand by the trimmers. In the smaller evaporators the slicing is often done at the time of paring by a slicing attachment applied to the parers.

In nearly all the evaporators the paring and trimming are done by women and girls.

TRIMMING.

In paring the fruit there is usually more or less skin left around the stem and calyx of the apples and any irregular places that may occur. There will be wormholes, decayed spots, and other blemishes which will detract from the appearance of the product, if allowed to remain. Even bruises are objected to by the most exacting operators. Hence all such defects are cut out as soon as the fruit is pared if the highest grade of product is expected. This is done with an ordinary straight-back, sharp-pointed knife, having a blade 2½ or 3 inches long.

BLEACHING.

The fumes of burning sulphur are employed not only to make the fruit white where the freshly cut surfaces have become discolored by contact with the air, but to prevent further discoloration after it is sliced. Sulphuring is also generally supposed to be necessary to destroy fungi and insects, though under present methods of handling this is open to question.

There are no definite standards governing the bleaching as to the time required, amount of sulphur necessary to accomplish the desired end, etc. The aim is to treat until enough of the fumes have been absorbed by the apples to prevent discoloration after they are sliced and exposed to the air. If it is found that the fruit is not retaining its clean, white appearance with the treatment that is being given, either the length of time that the fruit is kept in the bleacher is increased or more sulphur is burned in the customary time for bleaching. Due caution should be exercised, however, in this connection, inasmuch as the bleaching of desiccated fruits with sulphur fumes is open to criticism. The sale of fruit containing sulphurous acid in any considerable quantity is prohibited by the pure-food laws of some States, as well as being restricted in some of the foreign markets. The Federal pure-food law will also make definite restrictions. (See p. 33.)

In many cases the bleaching process is doubtless continued much longer than is necessary for the desired results. Until some definite standards are established and recognized, the greatest care should be exercised not to bleach more than the minimum required to maintain the desired color a reasonable length of time.

The allotted time for bleaching in a large number of evaporators, from which information has been secured, varies from twenty minutes to one and one-half hours. The more usual time appears to be about forty-five minutes. This, however, may be regulated in a measure by the amount of sulphur burned in a given time.

The estimates regarding the amount of sulphur used to bleach a ton of fruit vary from 4 or 5 pounds to 20 pounds, though but little information of a definite character is to be obtained at present.

The usual practice is to start the sulphur fumes by putting a few live coals into the receptacle used for the purpose, then adding a small piece or two of stick brimstone. Before this has all been vaporized, more is added. This is continued as long as the bleacher is in operation, sufficient heat being generated to vaporize the sulphur without the further addition of burning coals.

When apples are dried whole, without slicing or quartering, they require less bleaching than if they are to be sliced, inasmuch as the interior of the fruit does not come in contact with the air.

For the most satisfactory results it is essential that the fruit be put into the bleacher in the shortest possible time after the surface is exposed to the air by paring. If a long delay occurs the surface becomes discolored, in which case it does not regain its original whiteness in the bleaching process.

SLICING, QUARTERING, ETC.

After bleaching, the next step in preparing the fruit is slicing, unless instead of slicing it is quartered or dried whole, as is done to a limited extent. In preparing fruit for some of the smaller evaporators, as previously mentioned, the slicing is done when the fruit is pared; the bleaching then follows the slicing instead of preceding it.

The slices are one-fourth inch in thickness, and in the largest degree possible should be cut at right angles to the hole made through the axis of the apple when the core is removed by the parer, thus producing the "rings," which is the form most desired. Other things being equal that fruit is sliced the best which contains the largest proportion of "rings," and this point is given more or less weight in grading the finished product.

When it is desired to evaporate apples in quarters or sixths they are run through machines which cut them accordingly, the cutting being done in the opposite direction from the slicing; that is, in a direction parallel to instead of at right angles to the axis of the apple.

If they are to be dried whole, they are transferred from the bleacher directly to the drying compartment without further treatment.

DRYING THE FRUIT.

When the fruit has been placed in the drying compartment of an evaporator, of whatever type it may be, it has reached the most critical stage in the whole process of evaporation, and it is here that the greatest care and skill are required to insure the best possible results.

CAPACITY OF FLOOR SPACE AND RACKS.

In the case of kiln evaporators, the sliced fruit is evenly spread on the floor to the depth of from 4 to 6 inches. A kiln 20 feet square will hold the slices of from 120 to 150 bushels of fresh fruit, depending upon the amount of waste in the apples and the exact depth to which they are spread on the floor.

If the fruit is in quarters or is dried whole, it may be somewhat thicker on the floor, since in these forms it does not pack down as closely as the slices do and hence does not impede the circulation of hot air through it if the depth is somewhat increased.

In tower evaporators and other types where the fruit is handled on racks the slices are seldom placed much more than 1 inch in depth. A rack 4 feet square will hold from three-fourths of a bushel to a bushel.

The fruit is generally put on the floor of the kiln as fast as it is sliced, and the fire is started in the furnace below as soon as the floor is filled, or, in many cases, before it is entirely covered.

OILING THE FLOORS AND RACKS.

It is a common practice to treat the floor of kilns occasionally with tallow to prevent the fruit from sticking to it. This is done every few days, or as often as conditions appear to make it advisable. Sometimes a mixture of equal parts of tallow and boiled linseed oil is used for this purpose.

Another practice, with the same end in view, is to thoroughly scrub the floors as often as is necessary with water, using with it some one of the scouring soaps. This is preferred by some operators, who claim that oil or tallow discolors the fruit.

At each filling of the racks, where these are used, the surface of the wire netting is lightly wiped over with a cloth moistened in lard. This prevents the fruit from sticking to the netting and keeps it clean.

TEMPERATURE MAINTAINED.

The temperature maintained in kilns or other drying compartments, in actual practice is largely a matter of experience, not a factor governed by any definite standards or regulated in accordance with thermometer readings, as might be expected. In general, the object in view is to force the heat as high as possible without endangering the fruit. A probable temperature which has been suggested by some of the operators is 150° F., or more when the fruit is first put into the drying compartment, dropping to about 125° F. as the drying process nears completion. Sufficient and proper provision for controlling the indraft of cold air below the fruit will aid in maintaining the desired temperature.

TURNING THE FRUIT.

In order to prevent the fruit from burning and from sticking to the floor by remaining in contact with it too long, and to insure the most uniform drying that is possible, the fruit, in the case of the kiln driers, is turned occasionally. The interval between turnings varies with different operators, with the condition of the fruit, and with the degree of heat which is maintained. Some operators do not turn the fruit until 5 hours have elapsed after the furnace has been started, while a more common practice is to make the first turning within two to three hours after the drying is begun, or even sooner. For the first five or six hours it is generally turned every two hours or so, and more frequently as the fruit becomes drier, until perhaps it may require turning every half hour when nearly dry.

The objects to be obtained by turning must be kept in mind and the fruit handled accordingly. It should be examined from time to time and turned often enough to prevent scorching or sticking and to insure uniform drying.

In the case of the tower evaporators and other types in which the fruit is handled on racks, no turning more than an occasional stirring of the fruit with the hand or with a small wooden paddle is required. Sometimes the relative positions of the racks are changed to make the drying more uniform. This is one reason why the tower-dried fruit is generally of rather better quality than that from kilns. . The repeated turning on the kiln floor is likely to make the fruit more or less " mussy," while in that which remains practically undisturbed on the racks the rings are maintained in better condition. The fruit also dries more quickly, and is often of better color than the kiln-evaporated product, and hence is more attractive in appearance.

The same general principles must be observed in tending the fruit where steam heat is used in place of direct hot air from furnaces.

TIME REQUIRED FOR DRYING.

The time necessary for drying fruit depends upon several factors. The more important are: Type of evaporator; depth to which fruit is spread; method of preparing—whether sliced, quartered, or whole; temperature maintained; conditions of the weather, and, to a certain extent, the construction of the evaporator.

The application of these several factors to the point in question readily follows. A good kiln evaporator should dry a floor of slices, other things being equal, in about twelve hours, ten to fourteen hours being the range of variation. Where the fruit is handled on racks the time required is much shorter, but conditions are quite different from the kilns, as the fruit is seldom more than 1 or 2 inches thick on the racks. For slices, five hours is considered a reasonable time, with a range of four to six hours.

It is estimated that quarters will require from eighteen to twenty-four hours in the average kiln, while the time for whole apples will range from thirty-six to forty-eight hours.

If the atmospheric conditions are heavy and damp, the drying is retarded. Under some conditions it is hardly possible to thoroughly dry the fruit. During windy weather also it is more difficult to regulate the heat, especially if the walls are poorly constructed so that the draft of cold air into the furnace room can not be controlled. This applies especially to kilns heated by furnaces. It is claimed that steam-heated evaporators are less subject to the influence of climatic conditions.

WHEN IS THE FRUIT DRY?

Perhaps there is no step in the entire process that requires better-trained judgment than the matter of determining when the fruit is sufficiently dried to meet the requirements. Like several other steps in the process it is largely a matter of experience, though there are certain general features which are capable of being reduced to words.

The fruit should be so dry that when a handful of slices is pressed together firmly into a ball the slices will be " springy " enough to separate at once upon being released from the hand. In this condition there will be no fruit, or only an occasional piece, that has any visible moisture on the surface. In a slice of average dryness, it should not be possible to press any free juice into view in a freshly made cross section of it. The general " feel " of the fruit, as it is handled, should be a soft, velvety, leathery texture.

The foregoing should represent as nearly as possible the average condition, but it can not be expected to be absolutely uniform throughout. Some slices—they should constitute only a very small percentage—will still plainly possess some of the juice of the apple; others—likewise, properly only a small proportion—will be entirely too dry, possibly dry enough to be brittle.

THE CURING ROOM.

When a quantity of fruit is considered dry enough, it is removed from the kiln and put in a pile on the floor of the curing room. Every day or two the pile should be thoroughly shoveled over to make uniform the changes which take place. Thus managed, the pile in a few days will become thoroughly homogeneous. The pieces that were too dry will have absorbed moisture, the superfluous moisture of other pieces will have disappeared, and the entire mass may be expected to reach the condition above described.

HANDLING THE WASTE.

In the usual grades of apples that are taken to the evaporator there are many specimens that are too small to pare or which for other reasons can not be profitably used in this way. In the case of some of the larger evaporators which are operated in connection with vinegar factories, these apples, as well as all parings and trimmings, are used for "vinegar stock," but in the smaller ones these portions are usually dried. It is generally estimated that about one-third as much space is required to dry the parings and trimmings as is demanded for the "white fruit."[a]

"Waste" and "chops" are generally bleached, but are seldom passed through the bleacher which is used for the white fruit. Where they are dried in kilns, which is usually the case, a common way of bleaching is to burn the sulphur in the furnace room after the stock has been spread on the floor.

It is generally estimated that the waste from a given quantity of apples will pay the cost of the fuel for evaporating that quantity of fruit; that is, putting it on a bushel basis, the waste from a bushel will pay for fuel to evaporate both the white fruit and the waste from that bushel. While in some instances, when the price of such stock is low, this estimate may be too high, it not infrequently happens that it more than pays for the fuel.

---

[a] "White fruit" is a general term used by operators and dealers to denote the grades used for culinary purposes, in distinction from "waste," which comprises the parings and trimmings, and "chops," which are composed of the apples that are too small and otherwise defective to pare.

WEIGHT OF EVAPORATED APPLES.

Some varieties of apples will make more evaporated stock to the bushel than others. The grade used also affects the amount, but an average weight—a frequent basis of estimates—is about 6½ pounds of white fruit and 3½ pounds of waste to a bushel of fresh fruit. When the apples are dried whole, without slicing, they will make from 1 to 2 pounds more to the bushel than when sliced.

LAWS RELATING TO EVAPORATED FRUITS.

So far as the writer has been able to learn, only one State has enacted laws, aside from those relating to the presence of sulphurous acid or sulphites, regulating the quality or condition of evaporated or dried fruits offered for sale.

In 1904 the New York legislature amended the agricultural law so as to prohibit the sale of adulterated evaporated apples. This act became a law on April 26, 1904, and is recorded in Chapter 391. It is intended primarily to regulate the moisture content of evaporated fruit when offered for sale. For the purpose of the act, evaporated apples are considered " standard " if they do not contain more than 27 per cent of water or fluids as determined by drying for four hours at the temperature of boiling water.

It will thus be seen that evaporated apples, in the terms of this law, are considered " adulterated " if they contain more than 27 per cent of moisture.

The pure food laws of some States also apply in certain instances, especially those which make specifications in regard to the presence of sulphurous acid or sulphites in food products. This reference to the matter should be sufficient to call the attention of manufacturers and dealers to its importance.

A California statute, approved March 20, 1903, requires that all fruit, green or dried, contained in boxes, barrels, or packages, and offered for shipment in the State be so labeled as to designate the county and immediate locality in which the fruit was grown, but a decision of the supreme court of the State declares this law to be unconstitutional.

A decision of the Board of Food and Drug Inspection under the pure-food law enacted by the first session of the Fifty-ninth Congress of the United States relative to the maximum amount of sulphurous acid permissible in evaporated or desiccated fruits is now awaited with interest.

The attention of all interested persons, especially exporters, should further be called to the fact that " the governments of Prussia and

Saxony, in order to unify the practices of inspectors of desiccated fruits, have issued decrees fixing the limit of sulphurous acid in desiccated fruits at 0.125 per cent."[a]

The presence of sulphurous acid in desiccated fruits, and also of zinc in fruit dried on galvanized wire racks, has frequently been criticised in foreign markets and has been the source of unfavorable judgment, resulting in more or less agitation favoring laws restricting or prohibiting the sale of such fruit.

HANDLING EVAPORATED APPLES.

While comparatively few of the manufacturers of evaporated apples pack their own fruit for the trade, it will be of interest to them and of direct value to know something of the methods pursued by dealers, and especially in regard to grading and the requirements of the various grades.

The product of all grades is generally shipped to the dealers in gunny sacks having a capacity of 1½ or 2 bushels. The "white fruit" is usually bought by the pound. Sometimes the waste is rated by the hundredweight. The price paid is not governed by the market conditions alone; the quality is an important factor.

RANGE OF PRICES.

In 1904 the output of evaporated apples was very large and in excess of immediate trade demands. The prices were correspondingly low. Because of a light crop of apples in the season of 1905, the quantity of evaporated apples was relatively small. There was a large quantity of fruit evaporated in 1906, but trade conditions were rather unusual and prices varied accordingly. An idea of the range of prices at the evaporators is suggested by the following rates which prevailed in New York during the three seasons just mentioned:

Year.	White fruit, per pound.	Chops, per hundredweight.	Waste, per hundredweight.
	Cents.		
1904	3⅛ to 4⅛	$0.75 to $1.15	$0.60 to $0.85
1905	7 to 7¼	2	1 to 1.25
1906	4 to 7¼	1.75 to 2	.90 to 1.25

The market price of whole apples is usually a cent or more a pound higher than that for sliced fruit; quarters also bring a higher price.

In cases where special pains are taken in trimming and in other processes in preparing the fruit and the finished product is particularly white and clean, better prices than the prevailing market rates can often be obtained.

---

[a] Decision No. 7 of "Food Inspection Decisions 1–25," Bureau of Chemistry, U. S. Department of Agriculture.

GRADING.

In classifying evaporated apples, three grades are generally recognized, which are commonly designated as " fancy," " choice," and " prime." Two other grades, which in reality are special grades, are also sometimes recognized, viz, " extra fancy," and a lower grade than prime—usually called prime with some prefix, frequently the name of a locality, to distinguish it from that grade.

The standards demanded for these various grades are about as follows:

" Fancy " is very white, clean stock, free from all pieces of skin and other objectionable portions which should be removed in trimming, and a good proportion of the slices in rings.

" Choice " denotes a grade intermediate between " fancy " and " prime," not quite clean enough for " fancy," yet more nearly free from imperfections than the " prime " grade demands.

" Prime " must be good stock, well cured, and of a generally attractive appearance. It must be comparatively white and mostly free from undesirable portions, but stock having a small percentage of such defects is usually put in this grade.

" Extra fancy," as the name implies, is a fancy grade that is exceptionally fine. It must possess all the qualities mentioned in describing that grade in a marked degree. At least 85 per cent of the slices should be " rings."

The grade below " prime " is the stock that has been so carelessly handled and is so unattractive in appearance that it can not maintain the standard of " prime." It is packed for an entirely different and much poorer class of trade than any of the other grades.

KINDS OF PACKAGES USED.

In packing the fruit, several sizes of packages are in common use. While the proportionate dimensions of the packages may vary with the different dealers and packers, their capacity is more or less a matter of uniform standards.

Perhaps the package most used is the 50-pound wooden box. A common form of this box is 10½ by 11 by 22 inches, inside measure. Twenty-five-pound boxes are likewise much used; these are commonly made 9 by 9 by 18 inches, inside dimensions. A box holding 55 pounds of sliced fruit, having inside measurements of 11 by 11¾ by 22½ inches, is much used for the export trade. These are generally marked "25 kilos" when intended for export, instead of having the capacity designated in pounds.

Pasteboard cartons, holding 1 pound, or one-half kilo (1.1pounds) for certain export trade, are also more or less used for the better grades of sliced fruit. These cartons are generally packed in a box or case, 48 cartons to the case. The cartons are 2 by 5 by 7 inches; the case is about 12 by 16 by 21 inches.

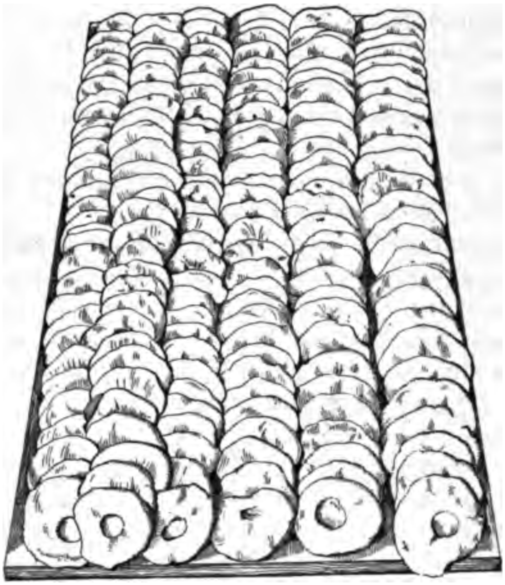


Fig. 11.—A "board" of facers.

All of these packages are used as desired for slices or "rings," but the quarters and whole fruit are generally packed in the 55-pound boxes, which, however, are expected to contain but 50 pounds of fruit in these forms.

PACKING.

The side of the box intended for the top or "face" is packed first, as in packing fresh fruit in boxes or barrels. The first step in packing, therefore, is to "face" this side. The "facers" are slices which are perfect rings. These are usually selected from a quantity of fruit which contains a relatively large proportion of them; they are then placed on thin boards which are slightly smaller than the top of the box, inside measure, overlapping one another in rows, lengthwise of the board. Figure 11 shows such a "board" of facers. The facers are put in place by inserting the board on which they are arranged into the box, which is first lined with paraffin paper, and then with a dexterous movement of the hand flipping the layer of rings against the inner face or the bottom, which is to become the top of the box.

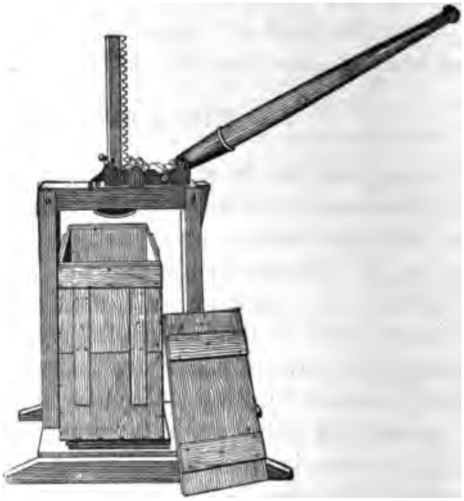


Fig. 12.—A press used in packing evaporated apples.

A press similar to figure 12 is generally used in filling the boxes. Three men compose a packing gang for each press; one to fill the boxes and weigh the fruit; one to operate the press; a third to nail on the cover, which now becomes the bottom of the box.

In filling the boxes, an extension of the box upward is necessary, since 50 pounds of evaporated apples have to be compressed greatly in order to get them into a box of the required dimensions. This extension may be another box of same size with a rim nailed around the edge to fit over the box to be filled. The box is placed on a pair of scales and filled with the desired quantity of fruit, by weight; it is then passed to the press. A " follower " slightly smaller than the box is put in position over the fruit and this is pressed down until the fruit reaches the desired point.

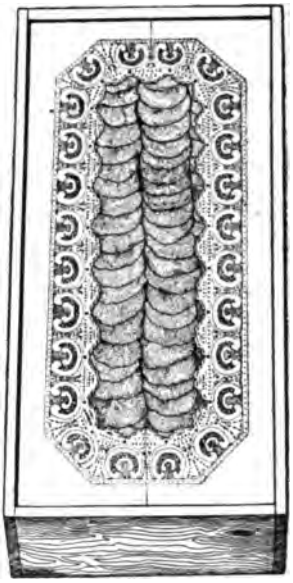


FIG. 13.—A 50-pound box of "fancy" evaporated apples with cover removed.

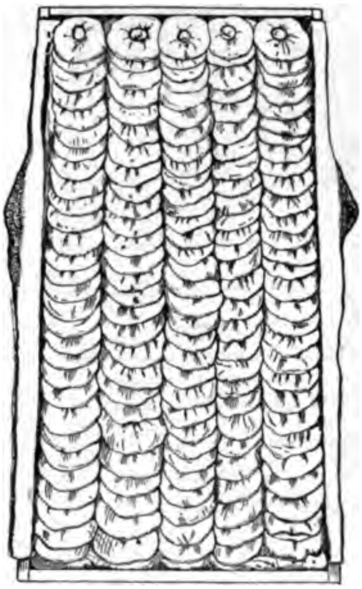


FIG. 14.—A 50-pound box of "fancy" evaporated apples with cover and paper lace removed.

Quarters and whole apples are handled in essentially the same manner except in regard to the facing. In facing whole apples they are placed on the side in rows lengthwise of the bottom (when packed, the top) of the box. The boxes are then filled the same as with slices. Quarters are handled in the same way.

Figure 13 is a box of fancy evaporated apples with cover removed, showing the paper lace used for decorative effect. Figure 14 is the same box with the paper covering entirely removed. Figures 15 and 16 show, respectively, a box of whole apples and one of quarters.

Cartons are filled by hand, the work usually being done on a table of convenient height. Each package is weighed to insure its proper content of fruit.

The sun-dried fruit, of which quite large quantities are handled by some dealers, is usually packed in sugar barrels. This is largely exported. The waste is also generally put into barrels, 240 to 250 pounds net usually filling a barrel. Chops are handled in a similar manner.

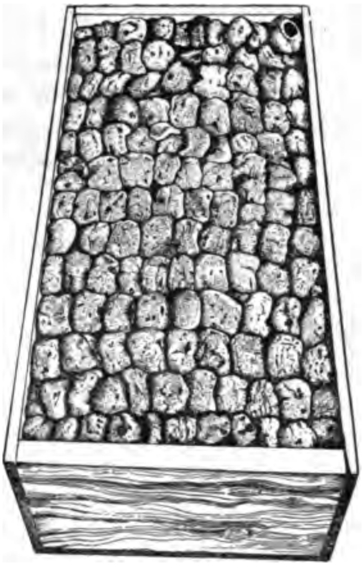


FIG. 15.—A 50-pound box of "prime" whole apples.

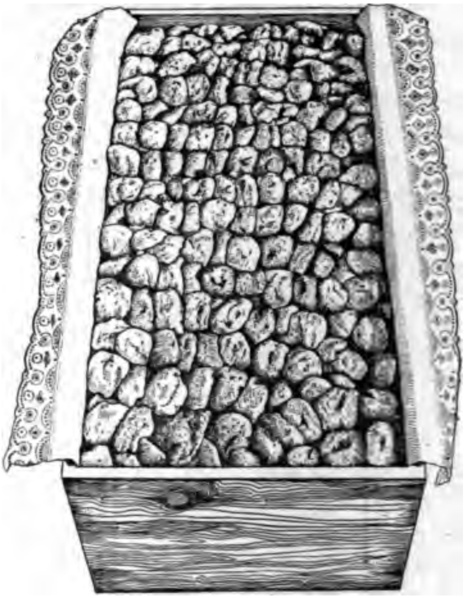


FIG. 16.—A 50-pound box of "prime" quarters.

STORING THE FRUIT.

In years of great abundance of apples, the evaporated product is likely to exceed the immediate demand. While fruit that has been well bleached and cured can be held for a considerable period of time without loss it is by no means imperishable. The color is first to deteriorate. The fruit appears to lose the effect of bleaching after a time and turns dark. Though it may retain its flavor for a long time, its unattractive appearance renders it more or less unsalable.

When it is desired to hold evaporated apples from one season to another, recourse is had to cold storage. Some seasons large quantities are handled in this way. The temperature at which it is stored is usually from 32° to 35° F., or about the same as for fresh fruit. If well bleached and properly cured it may be held for a relatively long period. Four or five years is said by commercial handlers to be about the usual limit of time before the color deteriorates. It is seldom, however, that it is desirable to hold the fruit for so long a time.

FARMERS' BULLETINS.

The following is a list of the Farmers' Bulletins available for distribution, showing the number, title, and size in pages of each. Copies will be sent free to any address in the United States on application to a Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

22. The Feeding of Farm Animals. Pp. 40.
24. Hog Cholera and Swine Plague. Pp. 16.
25. Peanuts: Culture and Uses. Pp. 24.
27. Flax for Seed and Fiber. Pp. 16.
28. Weeds and How to Kill Them. Pp. 30.
29. Souring and Other Changes in Milk. Pp. 22.
30. Grape Diseases on the Pacific Coast. Pp. 15.
32. Silos and Silage. Pp. 30.
33. Peach Growing for Market. Pp. 24.
34. Meats: Composition and Cooking. Pp. 31.
35. Potato Culture. Pp. 24.
36. Cotton Seed and Its Products. Pp. 16.
39. Onion Culture. Pp. 30.
41. Fowls: Care and Feeding. Pp. 24.
42. Facts About Milk. Pp. 32.
44. Commercial Fertilizers. Pp. 38.
46. Irrigation in Humid Climates. Pp. 27.
47. Insects Affecting the Cotton Plant. Pp. 32.
48. The Manuring of Cotton. Pp. 16.
49. Sheep Feeding. Pp. 24.
51. Standard Varieties of Chickens. Pp. 48.
52. The Sugar Beet. Pp. 48.
54. Some Common Birds. Pp. 48.
55. The Dairy Herd. Pp. 30.
56. Experiment Station Work—I. Pp. 30.
58. The Soy Bean as a Forage Crop. Pp. 24.
59. Bee Keeping. Pp. 48.
60. Methods of Curing Tobacco. Pp. 24.
61. Asparagus Culture. Pp. 40.
62. Marketing Farm Produce. Pp. 31.
63. Care of Milk on the Farm. Pp. 40.
64. Ducks and Geese. Pp. 55.
65. Experiment Station Work—II. Pp. 32.
66. Meadows and Pastures. Pp. 30.
68. The Black Rot of the Cabbage. Pp. 22.
69. Experiment Station Work—III. Pp. 32.
70. Insect Enemies of the Grape. Pp. 23.
71. Essentials in Beef Production. Pp. 24.
72. Cattle Ranges of the Southwest. Pp. 32.
73. Experiment Station Work—IV. Pp. 32.
74. Milk as Food. Pp. 39.
77. The Liming of Soils. Pp. 24.
78. Experiment Station Work—V. Pp. 32.
79. Experiment Station Work—VI. Pp. 27.
80. The Peach Twig-borer. Pp. 16.
81. Corn Culture in the South. Pp. 24.
82. The Culture of Tobacco. Pp. 22.
83. Tobacco Soils. Pp. 23.
84. Experiment Station Work—VII. Pp. 32.
85. Fish as Food. Pp. 32.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
91. Potato Diseases and Treatment. Pp. 15.
92. Experiment Station Work—IX. Pp. 30.
93. Sugar as Food. Pp. 31.
95. Good Roads for Farmers. Pp. 46.
96. Raising Sheep for Mutton. Pp. 48.
97. Experiment Station Work—X. Pp. 32.
98. Suggestions to Southern Farmers. Pp. 48.
99. Insect Enemies of Shade Trees. Pp. 30.
100. Hog Raising in the South. Pp. 40.
101. Millets. Pp. 30.
102. Southern Forage Plants. Pp. 48.
103. Experiment Station Work—XI. Pp. 30.
104. Notes on Frost. Pp. 24.
105. Experiment Station Work—XII. Pp. 32.
106. Breeds of Dairy Cattle. Pp. 48.
107. Experiment Station Work—XIII. Pp. 32.
108. Saltbushes. Pp. 20.
109. Farmers' Reading Courses. Pp. 20.
110. Rice Culture in the United States. Pp. 28.
111. Farmer's Interest in Good Seed. Pp. 24.
112. Bread and Bread Making. Pp. 40.
113. The Apple and How to Grow It. Pp. 32.
114. Experiment Station Work—XIV. Pp. 28.
115. Hop Culture in California. Pp. 28.
116. Irrigation in Fruit Growing. Pp. 48.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 30.
120. Insects Affecting Tobacco. Pp. 32.
121. Beans, Peas, and other Legumes as Food Pp. 38.
122. Experiment Station Work—XVI. Pp. 32.
124. Experiment Station Work—XVII. Pp. 32.
125. Protection of Food Products from Injurious Temperatures. Pp. 24.
126. Practical Suggestions for Farm Buildings. Pp. 48.
127. Important Insecticides. Pp. 46.
128. Eggs and Their Uses as Food. Pp. 40.
129. Sweet Potatoes. Pp. 40.
131. Household Tests for Detection of Oleomargarine and Renovated Butter. Pp. 10.
132. Insect Enemies of Growing Wheat. Pp. 38.
133. Experiment Station Work—XVIII. Pp. 32.
134. Tree Planting in Rural School Grounds. Pp. 32.
135. Sorghum Sirup Manufacture. Pp. 40.
136. Earth Roads. Pp. 24.
137. The Angora Goat. Pp. 48.
138. Irrigation in Field and Garden. Pp. 40.
139. Emmer: A Grain for the Semiarid Regions. Pp. 16.
140. Pineapple Growing. Pp. 48.
141. Poultry Raising on the Farm. Pp. 16.
142. Principles of Nutrition and Nutritive Value of Food. Pp. 48.
143. Conformation of Beef and Dairy Cattle. Pp. 44.
144. Experiment Station Work—XIX. Pp. 32.
145. Carbon Bisulphid as an Insecticide. Pp. 28.
146. Insecticides and Fungicides. Pp. 16.
147. Winter Forage Crops for the South. Pp. 40.
149. Experiment Station Work—XX. Pp. 32.
150. Clearing New Land. Pp. 24.
151. Dairying in the South. Pp. 48.
152. Scabies in Cattle. Pp. 32.
153. Orchard Enemies in the Pacific Northwest. Pp. 39.
154. The Home Fruit Garden: Preparation and Care. Pp. 16.
155. How Insects Affect Health in Rural Districts. Pp. 19.
156. The Home Vineyard. Pp. 22.
157. The Propagation of Plants. Pp. 24.
158. How to Build Small Irrigation Ditches. Pp. 28.
159. Scab in Sheep. Pp. 48.
161. Practical Suggestions for Fruit Growers. Pp. 30.
162. Experiment Station Work—XXI. Pp. 32.
164. Rape as a Forage Crop. Pp. 16.
165. Silkworm Culture. Pp. 32.
166. Cheese Making on the Farm. Pp. 16.
167. Cassava. Pp. 32.
168. Pearl Millet. Pp. 16.
169. Experiment Station Work—XXII. Pp. 32.
170. Principles of Horse Feeding. Pp. 44.
172. Scale Insects and Mites on Citrus Trees. Pp. 43.
173. Primer of Forestry. Pp. 48.
174. Broom Corn. Pp. 30.
175. Home Manufacture and Use of Unfermented Grape Juice. Pp. 16.
176. Cranberry Culture. Pp. 20.
177. Squab Raising. Pp. 32.
178. Insects Injurious in Cranberry Culture. Pp. 32.
179. Horseshoeing. Pp. 30.
181. Pruning. Pp. 39.
182. Poultry as Food. Pp. 40.

183. Meat on the Farm: Butchering, Curing, and Keeping. Pp. 37.
184. Marketing Live Stock. Pp. 40.
185. Beautifying the Home Grounds. Pp. 24.
186. Experiment Station Work—XXIII. Pp. 32.
187. Drainage of Farm Lands. Pp. 38.
188. Weeds Used in Medicine. Pp. 45.
190. Experiment Station Work—XXIV. Pp. 32.
192. Barnyard Manure. Pp. 32.
193. Experiment Station Work—XXV. Pp. 32.
194. Alfalfa Seed. Pp. 14.
195. Annual Flowering Plants. Pp. 48.
196. Usefulness of the American Toad. Pp. 16.
197. Importation of Game Birds and Eggs for Propagation. Pp. 30.
198. Strawberries. Pp. 24.
199. Corn Growing. Pp. 32.
200. Turkeys. Pp. 40.
201. Cream Separator on Western Farms. Pp. 23.
202. Experiment Station Work—XXVI. Pp. 32.
203. Canned Fruits, Preserves, and Jellies. Pp. 32.
204. The Cultivation of Mushrooms. Pp. 24.
205. Pig Management. Pp. 40.
206. Milk Fever and Its Treatment. Pp. 16.
208. Varieties of Fruits Recommended for Planting. Pp. 48.
209. Controlling the Boll Weevil in Cotton Seed and at Ginneries. Pp. 32.
210. Experiment Station Work—XXVII. Pp. 32.
211. The Use of Paris Green in Controlling the Cotton Boll Weevil. Pp. 23.
213. Raspberries. Pp. 38.
215. Alfalfa Growing. Pp. 40.
216. The Control of the Boll Weevil. Pp. 32.
217. Essential Steps in Securing an Early Crop of Cotton. Pp. 16.
218. The School Garden. Pp. 40.
219. Lessons from the Grain Rust Epidemic of 1904. Pp. 24.
220. Tomatoes. Pp. 32.
221. Fungous Diseases of the Cranberry. Pp. 16.
222. Experiment Station Work—XXVIII. Pp. 32.
223. Miscellaneous Cotton Insects in Texas. Pp. 24.
224. Canadian Field Peas. Pp. 16.
225. Experiment Station Work—XXIX. Pp. 32.
226. Relation of Coyotes to Stock Raising in the West. Pp. 24.
227. Experiment Station Work—XXX. Pp. 32.
228. Forest Planting and Farm Management. Pp. 22.
229. The Production of Good Seed Corn. Pp. 24.
231. Spraying for Cucumber and Melon Diseases. Pp. 24.
232. Okra: Its Culture and Uses. Pp. 16.
233. Experiment Station Work—XXXI. Pp. 32.
234. The Guinea Fowl. Pp. 24.
235. Preparation of Cement Concrete. Pp. 32.
236. Incubation and Incubators. Pp. 32.
237. Experiment Station Work—XXXII. Pp. 32.
238. Citrus Fruit Growing in the Gulf States. Pp. 48.
239. The Corrosion of Fence Wire. Pp. 32.
240. Inoculation of Legumes. Pp. 8.
241. Butter Making on the Farm. Pp. 32.
242. An Example of Model Farming. Pp. 16.
243. Fungicides and their Use in Preventing Diseases of Fruits. Pp. 32.
244. Experiment Station Work—XXXIII. Pp. 32.
245. Renovation of Worn-out Soils. Pp. 16.
246. Saccharine Sorghums for Forage. Pp. 37.
247. The Control of the Codling Moth and Apple Scab. Pp. 21.
248. The Lawn. Pp. 20.
249. Cereal Breakfast Foods. Pp. 36.
250. The Prevention of Wheat Smut and Loose Smut of Oats. Pp. 16.
251. Experiment Station Work—XXXIV. Pp. 32.
252. Maple Sugar and Sirup. Pp. 36.
253. The Germination of Seed Corn. Pp. 16.
254. Cucumbers. Pp. 30.
255. The Home Vegetable Garden. Pp. 47.
256. Preparation of Vegetables for the Table. Pp. 48.
257. Soil Fertility. Pp. 39.
258. Texas or Tick Fever and Its Prevention. Pp. 45.
259. Experiment Station Work—XXXV. Pp. 32.
260. Seed of Red Clover and Its Impurities. Pp. 24.
261. The Cattle Tick. Pp. 22.
262. Experiment Station Work—XXXVI. Pp. 32.
263. Practical Information for Beginners in Irrigation. Pp. 40.
264. The Brown-tail Moth and How to Control It. Pp. 22.
265. Game Laws for 1906. Pp. 54.
266. Management of Soils to Conserve Moisture. Pp. 30.
267. Experiment Station Work—XXXVII. Pp. 32.
268. Industrial Alcohol: Sources and Manufacture. Pp. 45.
269. Industrial Alcohol: Uses and Statitisca. Pp. 29.
270. Modern Conveniences for the Farm Home. Pp. 48.
271. Forage Crop Practices in Western Oregon and Western Washington. Pp. 39.
272. A Successful Hog and Seed-Corn Farm. Pp. 16.
273. Experiment Station Work—XXXVIII. Pp. 32.
274. Flax Culture. Pp. 36.
275. The Gipsy Moth and How to Control It. Pp. 22.
276. Experiment Station Work—XXXIX. Pp. 32.
277. The Use of Alcohol and Gasoline in Farm Engines. Pp. 40.
278. Leguminous Crops for Green Manuring. Pp. 27.
279. A Method of Eradicating Johnson Grass. Pp. 16.
280. A Profitable Tenant Dairy Farm. Pp. 16.
281. Experiment Station Work—XL. Pp. 32.
282. Celery. Pp. 36.
283. Spraying for Apple Diseases and the Codling Moth in the Ozarks. Pp. 42.
284. Insect and Fungous Enemies of the Grape East of the Rocky Mountains. Pp. 48.
285. The Advantage of Planting Heavy Cotton Seed. Pp. 16.
286. Comparative Value of Whole Cotton Seed and Cotton-Seed Meal in Fertilizing Cotton. Pp. 14.
287. Poultry Management. (In press.)
288. Nonsaccharine Sorghums. Pp. 28.
289. Beans. Pp. 28.

O

Issued May 22, 1907.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 292.

COST OF FILLING SILOS.

BY

LYMAN CARRIER,
*Scientific Assistant, Farm Management Investigations,
Bureau of Plant Industry.*

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., March 30, 1907.

SIR: I have the honor to transmit herewith a paper entitled "Cost of Filling Silos," by Mr. Lyman Carrier, Scientific Assistant, prepared under the direction of the Agriculturist in Charge of Farm Management Investigations, and recommend that it be published as a Farmers' Bulletin.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

B. P. I.—278.

COST OF FILLING SILOS.[a]

INTRODUCTION.

The data contained in the following pages were gathered in the months of September of 1905 and 1906. The writer visited all of the thirty-one farms mentioned in this paper and took notes on the number and arrangement of men and teams, the machinery used, and the length of time taken, and he also made measurements of the silos, etc. Information in regard to the quantities of twine and fuel used and the number of acres cut was given by each individual farmer.

It was thought advisable to confine this inquiry to localities in which the silo has been in use for several years. The places chosen were in Jefferson and Fond du Lac counties, Wisconsin, and in Branch and Lewanee counties, Michigan.

METHODS EMPLOYED.

The methods employed by the different farmers in filling their silos varied greatly, no two being exactly alike. This was occasioned largely by scarcity of help or teams and by the kind of machinery used. With a few exceptions the different methods may be classified in three groups:

(1) The most common practice was to have one man with three horses on a corn harvester cutting corn in the field; two men to load the wagons in the field; three or four men with teams, depending on the distance from the field to the silo, to haul the corn to the cutter; one man to run the engine when steam was used for power, and, occasionally, when gasoline engines were used, one man to feed the cutter and one man in the silo to spread and tramp the silage. Each teamster pitched off his own load. This makes a crew of eight or nine men, exclusive of the man who tends the engine.

(2) In cases where there is a shortage of teams the following method is generally practiced. One man, with three horses, cuts the

---

[a] For details in reference to the construction of silos, the feeding of silage to farm stock, etc., see Farmers' Bulletin 32, entitled "Silos and Silage."

corn; two men load the wagons in the field; two men, or boys, with teams, haul the corn to the cutter; one man unloads the wagons; one man feeds and one man works in the silo. As soon as a load arrives at the cutter the teamster changes his team for an empty wagon and goes back to the field after another load. When a wagon is unloaded it is run out of the way by hand. With this method boys who are not strong enough to handle the green corn can be utilized to drive the teams. This method requires a crew of six men and two boys, exclusive of the engine tender.

(3) When enough horses are available and help is scarce, the following arrangement of men and teams is a good one. One man, with three horses, runs the harvester in the field; four men with teams haul the corn to the silo; one man feeds and one spreads the corn in the silo. Low trucks or wagons with racks suspended below the axles should be used, so that the teamsters can put on their own loads. (See fig. 1.) This requires a crew of seven men, besides the engineer.

Table 1 gives a comparison of these three methods.

TABLE 1.—*Number and arrangement of men employed in filling silos by various methods.*

Kind of work.	Method 1.	Method 2.	Method 3.
Operating binder	1	1	1
Loading wagons	2	2	0
Driving teams	3 or 4	2 (boys)	4
Unloading wagons	Teamsters.	1	Teamsters.
Feeding cutter	1	1	1
In silo	1	1	1
Total number of men	8 or 9	8	7
Number of teams hauling	3 or 4	2	4

The difference between methods is in the arrangements for loading, hauling, and unloading. When there is a sufficient number of teams, the teamsters do their own loading and unloading. When teams are scarce, two loaders and one unloader are needed; but boys may drive [illegible]

[illegible] measured and the [illegible] It must be borne [illegible] actual weights [illegible] per cent greater [illegible]

[illegible] to compare the [illegible] was made for [illegible] hire was rated [illegible] may be too high [illegible] attention all of [illegible] out of order than did the steam engines, which probably offset the difference in attention demanded.

Twine was rated at 11½ cents a pound, coal at $5 a ton, and gasoline at 13 cents a gallon. No charge was made for wear and tear on machinery or for boarding the help. Nearly every one of these men owned his silage cutter. The others depended on hiring cutters. The charge for an engine, engineer, silage cutter, and one man to feed is usually $10 a day.

Ten hours were considered a day's work. No deductions were made for delays unless the helpers were set at some other work. The average quantity of silage cut daily by each man was computed by dividing the number of tons of silage cut by the total hours worked and multiplying the result by ten.

TABLE 2.—*Itemized statement of the equipment, etc., used in filling silos on 31 farms, with cost per ton of silage. (Arranged in order of total cost.)*

No. of farm.	Length of haul.	Silage cut.			Area cut.	Yield per acre.	Number of days cutting.	Kind of engine.	Size of engine.	Kind of fuel.	Length of cylinder.	Length of cut.	Kind of elevator.	Cost per ton of silage.					
		Total quantity.	Daily quantity.	Daily quantity per man.										Labor.	Teams.	Twine.	Fuel.	Engine hire.	Total.
	Rods.	*Tons.*	*Tons.*	*Tons.*	*Acres.*	*Tons.*			*H. P.*		*Inches.*	*Inches.*							
1	60	285	57	6.95	22	12.94	5	Gasol...	15	Gasol...	15	[illegible]	Blower.....	$0.21	$0.12	$0.03	$0.02	$0.08	$0.46
2	10	43	43	6.14	4	10.75	1	Gasol...	10	Gasol...	13	[illegible]	Blower.....	.23	.07	.03	.03	.12	.48
3	30	103	68.7	6.88	14	7.4	1.5	Steam..	16	Coal....	17	[illegible]	Blower.....	.22	.12	.05	.03	.07	.49
4	50	90	60	7.15	14	6.4	1.5	Steam..	12	Coal....	15	[illegible]	Blower.....	.21	.13	.05	.04	.08	.51
5	40	242	44	6.83	20	12.1	5.5	Steam..	12	Coal....	15	[illegible]	Blower.....	.22	.13	.03	.03	.10	.51
6	80	169	48.4	6.05	15	11.3	3.5	Steam..	10	Wood...	18	[illegible]	Carrier.....	.25	.12	.03	.02	.09	.51
7	30	140	61	7.42	16	8.75	2.3	Steam..	10	Coal....	18	[illegible]	Carrier.....	.20	.17	.03	.05	.08	.53
8	30	180	48	6.48	20	9	3.75	Steam..	12	Coal....	13	1	Carrier.....	.23	.16	.05	.02	.09	.55
9	30	103	37.5	6.15	12	8.6	2.75	Steam..	12	Coal....	16	[illegible]	Carrier.....	.25	.14	.03	.02	.12	.56
10	20	130	52	5.2	8	16.3	2.5	Gasol...	10	Gasol...	13	[illegible]	Blower.....	.29	.13	.02	.02	.10	.56
11	80	630	47.8	5.68	57	12.5	13.2	Gasol...	12	Gasol...	20	[illegible]	Carrier.....	.26	.15	.03	.03	.09	.56
12	40	205	34.2	6.51	21	9.8	6	Steam..	10	Coal....	18	[illegible]	Carrier.....	.24	.14	.04	.04	.13	.59
13	240	123	61.5	5.6	20	6.1	2	Steam..	12	Coal....	15	[illegible]	Blower.....	.27	.18	.05	.03	.07	.60
14	60	135	54	5.4	16	8.5	2.5	Steam..	10	Coal....	20	[illegible]	Carrier.....	.28	.16	.05	.03	.08	.60
15	30	325	46.5	5.33	19	17.1	7	Steam..	12	Coal....	15	[illegible]	Blower.....	.28	.14	.04	.06	.10	.62
16	120	810	57.8	4.45	85	9.6	14	Steam..	12	Coal....	20	[illegible]	Carrier.....	.34	.16	.00	.05	.08	.63
17	80	123	49.3	5.37	18	6.4	2.5	Steam..	10	Coal....	20	[illegible]	Carrier.....	.28	.17	.07	.03	.09	.64
18	30	450	42.8	4.13	33	13.6	10.5	Steam..	12	Coal....	22	[illegible]	Carrier.....	.36	.13	.04	.03	.11	.67
19	80	130	47.3	4.58	20	6.5	2.75	Steam..	20	Coal....	15	[illegible]	Blower.....	.33	.14	.04	.07	.09	.67
20	50	177	28.5	5.9	20	8.9	6	Gasol...	15	Gasol...	15	[illegible]	Blower.....	.25	.20	.05	.03	.15	.68
21	100	90	32.7	4.5	10	9	2.75	Gasol...	10	Gasol...	10	[illegible]	Carrier.....	.33	.16	.04	.03	.14	.70
22	120	640	42.7	4.25	85	7.5	15	Steam..	12	Coal....	15	[illegible]	Blower.....	.35	.18	.03	.03	.11	.70
23	30	148	33	4.49	18	8.2	4.5	Gasol...	8	Gasol...	18	[illegible]	Carrier.....	.33	.16	.05	.03	.14	.71
24	80	130	25	4.65	15	8.7	5	Steam..	10	Coal....	15	[illegible]	Carrier.....	.28	.20	.04	.03	.17	.72
25	320	68	34	3.43	7	9.7	2	Gasol...	10	Gasol...	15	[illegible]	Blower.....	.44	.16	0	.02	.13	.75
26	45	114	41.5	4.08	13.5	8.5	2.75	Steam..	12	Coal....	20	[illegible]	Carrier.....	.36	.20	.07	.03	.11	.77
27	80	350	35	4.38	30	11.6	10	Gasol...	15	Gasol...	16	1	Carrier.....	.34	.22	.05	.04	.13	.78
28	160	70	46.7	3.59	9	7.8	1.5	Steam..	10	Wood...	13	[illegible]	Blower.....	.42	.18	.04	.06	.10	.80
29	40	135	30	3.91	20	6.8	4.5	Steam..	10	Coal....	18	[illegible]	Carrier.....	.38	.18	.06	.05	.15	.82
30	60	195	30	3.75	25	7.8	6.5	Gasol...	11	Gasol...	16	[illegible]	Carrier.....	.40	.21	.05	.03	.15	.84
31	60	60	40	3.33	11	5.6	1.5	Steam..	10	Coal....	17	[illegible]	Carrier.....	.45	.20	.04	.05	.12	.86

The average yield of silage per acre was 9.01 tons. The average cost per ton of silage was 64 cents. The average amount of silage cut daily per man was 4.9 tons. The average cost per acre for putting the corn in the silo was $5.98.

ARRANGEMENT OF LABOR.

The following table shows the distribution of the men employed in cutting, loading, hauling, feeding, etc.:

TABLE 3.—*Arrangement of labor in filling silos on 31 farms.*

No. of farm.	Cutting corn.		Loaders.	Hauling—men and teams.	Pitching off.	Feeders.	In silo.	Engineers.	Total number of men.	Remarks.
	Men.	Horses.								
1	1	3	2	3	Teamsters.	1	0	0	7	
2	1	2	1	1	2	1	1	1	8	
3	1	3	2	4	1	1	1	1	11	Teamsters helped unload.
4	1	3	2	4	Teamsters.	1	1	1	10	
5	1	3	2	3	Teamsters.	1	1	1	9	
6	1	3	2	3	Teamsters.	1	1	1	9	
7	1	4	0	4	Teamsters.	1	1	1	8	Changed teams on binder every hour.
8	1	3	1	3	Teamsters.	1	1	1	8	
9	1	3	2	3	Teamsters.	1	1	1	9	
10	1	3	2	3	Teamsters.	[a] 2	2	1	11	
11	1	3	3	3	Teamsters.	1	0	0	8	Had man in silo last two days.
12	1	3	2	2	1	1	1	0	8	One boy drove team.
13	1	3	3	6	Teamsters.	1	1	1	13	
14	1	3	2	4	Teamsters.	1	1	1	10	
15	1	3	3	3	Teamsters.	1	1	1	10	
16	1	2	3	5	Teamsters.	[a] 2	2	1	14	Did not use any twine.
17	1	3	3	4	Teamsters.	0	2	1	11	Engineer helped feed the cutter.
18	1	3	2	2	1	1	1	1	9	Two men in silo last two days.
19	1	3	3	3	Teamsters.	[a] 2	2	1	12	
20	1	3	0	3	1	0	1	0	6	
21	1	3	3	2	Teamsters.	[a] 2	0	0	8	
22	1	3	2	4	Teamsters.	1	2		11	
23	1	3	2	2	1	1			9	
24	1	3	2	2	1	1		0	8	One boy drove team.
25	3	3	2	4	Teamsters.	1	2		13	Binder failed: cut mostly by hand.
26	1	3	2	4	Teamsters.	1	2		11	One man in silo first day.
27	1	3	1	3	Teamsters.	1			8	
28	1	3	4	4	Teamsters.	[a] 2	2		14	
29	1	3	2	2	1	1			9	
30	2	4	1	4	Teamsters.	1			10	Three teams hauling first 2½ days.
31	1	3	3	4	Teamsters.	[a] 2	2		13	

[a] Cutter did not have self-feeding attachment.

The question at once arises, Why can some farmers fill their silos at a cost of 46 cents a·ton while it costs others 86 cents? Quite often the higher cost is due to unavoidable causes, such as long hauls, lodged and tangled corn, and accidents to machinery. In many cases, however, a poor arrangement of the help is responsible for the extra expense. The best method is that in which the working force is the most evenly balanced; that is, where all are working continually. It is not necessary that men and teams should be rushed to their fullest extent in order to get the work done cheaply. Some of the most expensive work was conducted with the greatest furore and hurry. The scheme where all are working and no one is hindered by the others is the most economical. Too many men in the field for the number at the cutter, or vice versa, and too large a crew for the size of the silage cutter are common sources of loss. Two or three men and teams with loaded wagons waiting their turns to unload, a similar condition in the field where they are waiting to be loaded, or a delay owing to a lack of teams represents a decided loss of valuable time. The factor that controls the size of the crew is the capacity of the silage cutter.

At farm No. 28 too many men were employed (see Table 3). If there had been only two men instead of four pitching on in the field, three men instead of four with teams hauling, and one man instead of two in the silo, just as much silage could have been cut in the same length of time. The cutter was of medium size—too small for the number of men supposed to be at work. Deducting the wages of the four men and one team that were not needed would lower the cost of filling at this place from 80 cents to 64 cents a ton.

A small cutter may be used almost as economically as a large one, but most farmers wish to get the silo filling done as quickly as possible and so prefer the larger machines. There was only 2 cents per ton difference between the cost on farms 7 and 8, yet at No. 7 a new machine with an 18-inch cylinder was used, while at No. 8 a 13-inch cylinder machine that had been in service eighteen years was still in use.

SIZE OF LOADS.

There seems to be an inverse ratio between the size of loads hauled and the cost per ton for filling. It is unfortunate that a record of the total number of loads was not kept for each farm. The importance of this feature was not fully appreciated at the beginning of the study. The table below gives the average size of load on ten farms where such a record was kept. As before stated, the weights given are for cured silage and are not the weights of the green corn as it comes from the field.

TABLE 4.—*Relation of size of loads to total cost of silage.*

No. of farm.	Size of loads.	Cost per ton of silage.	No. of farm.	Size of loads.	Cost per ton of silage.
	Tons.			*Tons.*	
1	1.37	$0.46	16	0.72	$0.63
2	1.54	.48	19	.76	.67
4	1.00	.51	26	.75	.77
10	1.16	.56	28	.90	.80
15	.94	.62	31	.77	.86

The extra large loads hauled at farm No. 2 kept the cost remarkably low. There was only one team with two wagons hauling. Had smaller loads been drawn, the help of the eight men employed could not have been utilized to good advantage. The me and machinery at farm No. 14, where the cost was 60 ce almost identically the same as those at No. 26, where the 77 cents. No record was kept of the total number of loa at these two farms, but the loads at farm No. 26 were muc than those at No. 14, owing to a steep hill that had to be c reach the cutter. It is difficult to explain in any other difference in cost of 17 cents a ton at these two farms.

CROPS USED.

At farm No. 22 a 20-acre field of alfalfa was ready to c filling time. The owner tried the experiment of putting alfalfa in the silo, mixing it with corn. The alfalfa was c mowing machine and raked into windrows with a 2-horse One man with a team was set to hauling the alfalfa while t hauling corn. It is not a difficult matter for one man to load of this green stuff alone. The man who did this wc bring in five big loads a day, estimated at 2 tons each. The and teams hauling corn, with two loaders in the field, wc from 35 to 40 loads in that time. The silo was an extra over 38 feet in diameter, and so the two crops were qui mixed.

Corn alone was used at all of the other farms. There is able difference of opinion as to the relative value of differ ties of corn for silage. Some farmers grow very large south that do not mature grain in latitudes as far north as Micl Wisconsin. Others prefer the ordinary dent sorts which large percentage of grain. The total amount of digestib per acre is about the same, whether it is a large ensilage cc ordinary field variety, the difference in bulk being most Some farmers combine the two by planting 1 part of s southern variety and 2 parts of common field corn. This make a very satisfactory silage.

CONDITION OF THE CROPS WHEN CUT.

A few years ago it was thought necessary to ensilage c immature state in order to have it keep. This made a s with a strong pungent odor. The consensus of opinion n letting the corn go until the grain is fully matured. In ordi sons there is a period, lasting but a few days, in which the are ripe and the leaves and stalks are green. This is the i for putting it in the silo. If the corn is allowed to matu this stage, water should be added to the cut material at fi to prevent "fire fanging" of the silage. The results of many chemical analyses show that the food materials in the corn plant increase very rapidly as the plant approaches maturity, and do not reach their maximum until it is fully ripe. Most feeders prefer the silage made from mature corn because it contains less acid and possesses a milder odor than it does when cut in a greener condition.

EQUIPMENT.

HARVESTERS.

With the price of labor high and help difficult to obtain it becomes necessary to take advantage of all the labor-saving machinery possible. The corn binder has come to be almost indispensable at silo-filling time. Most of the farmers whose work is described herein owned their own harvesters. The others were able to hire them.

The cost of cutting corn with a machine is about the same as when it is cut by hand and laid in small bunches on the ground. But there is a considerable saving of time in handling bundles rather than loose stalks. It takes fully twice as long to unload the same quantity of corn when loose as when in bundles. At farm No. 16 (Table 2) the corn was cut with a harvester, but no twine was used. It is evident that the increased cost of labor more than offset the saving of three or four cents per ton of silage for twine. Several inventors are trying to construct a corn harvester with an elevator attachment to load the corn as soon as cut on a wagon driven alongside. Some of these machines give promise of success.

WAGONS.

Until a loader has been perfected the style of wagon used in hauling needs careful consideration. The rack should be as low as possible. A low, solid-wheel truck gives good satisfaction on smooth, level farms, with short hauls. The draft is too heavy for other conditions.

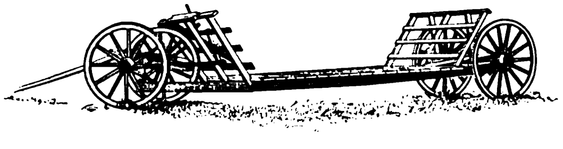


FIG. 1.—Rack for hauling green corn.

The rack that is quite commonly used in Wisconsin, figure 1, consists of two 4 by 6 inch bed pieces, 18 or 20 feet in length, bolted together at one end to form a V. On top of these timbers is built a rack 6 feet in width. The bottom of this rack is about 8 feet long. The end boards are 4 feet high, built flaring so they do not quite touch the wheels. The apex of the V is suspended below the front axle of an ordinary farm wagon by means of a long kingbolt. The other ends are attached below the hind axle by U-shaped clevises. This rack can be easily made. The materials needed in its construction are 80 board feet of 4 by 6 inch plank, 96 feet of boards 1 by 12 inches, 22 feet of lumber 2 by 4 inches, 1 long kingbolt, 2 stirrup rods, and bolts and nails.

Hauling green corn is heavy, tiresome work, and too much attention can not be paid to details of method in order to avoid unnecessary lifting. Before the advent of the corn harvester, when the corn was cut by hand and hauled unbound, it was a common practice to have the cutter set on a platform about 2½ feet above the ground. A man could pick up an armful of corn on the wagon and stepping on the platform place it on the feeding table. With the corn bound in bundles this arrangement causes much extra labor; nevertheless many farmers still keep the cutter upon the platform and lift the corn up to it when they could much more easily drop it on the table if the cutter were down on the ground.

SILAGE CUTTERS.

There are several first-class silage cutters on the market—machines that will cut the corn as fast as two men can pitch it on the table. The self-feeding table that is found on most of the modern cutters saves the labor of at least one man. This table should be long enough to hold two bundles of corn lapped at the bands.

ELEVATORS.

There are two types of elevators in general use. One is the old-style slat, or rattle carrier, and the other is the blower, in which the cut corn is forced up through a tube by means of a current of air. (See figs. 2 and 3.) The chief objection to the blower machine is that it takes so much power to run it. While the blower requires more power to operate than does the slat carrier, very few blowers require more than a 12-horsepower engine. With but one exception the power used on any one of these 31 farms would have been sufficient to run a medium-sized blower machine, and in most cases would have handled the largest machines without any trouble. It is interesting to note that blower machines were used by the five men having the lowest cost per ton of silage. Where the carrier elevators were used it cost on an average 65 cents per ton to fill the silo, while it cost those who used the blower elevators 61 cents. A carrier unless covered on top and fitted with a return trough underneath is very untidy, especially during windy weather. At one place there was litter to the depth of half a foot about the silo that had blown out of the carrier. This trouble is avoided by the use of the blowers.

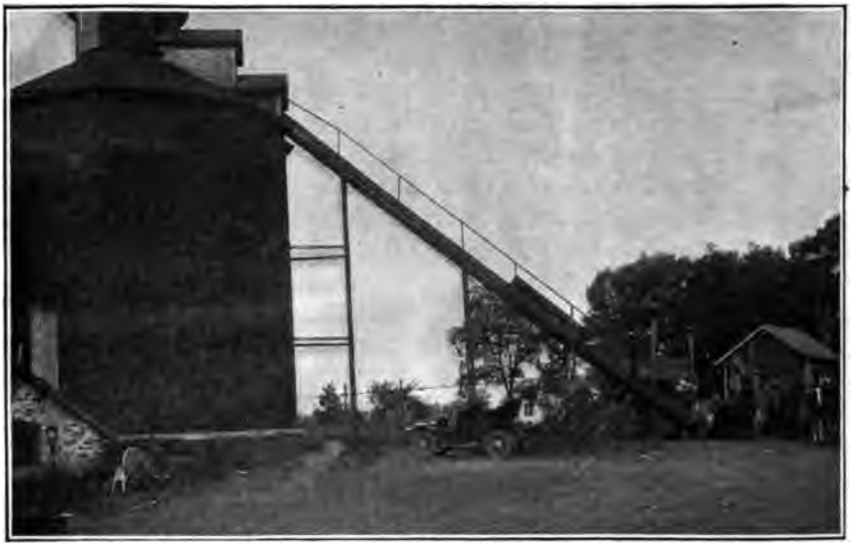


FIG. 2.—Filling a silo by means of a slat elevator having a closed top and return trough underneath.

The blower pipe should stand as nearly perpendicular as possible. In one case that was called to the writer's attention a blower at first proved unsatisfactory. The trouble lay in having the cutter set too far from the silo, with the pipe leaning at an angle of 30 degrees from the perpendicular. The pipe clogged frequently, and a 12-horsepower engine was insufficient to handle the cutter when [illegible] crowded to any[illegible] [illegible]ke its full ca[illegible] After two days [illegible]vance and dis[illegible]ment the owner [illegible]ed the position of [illegible] machine, putting [illegible]ose to the silo. [illegible] ifference could be [illegible] ack of power, [illegible]

SILAGE DISTRIBUTERS.

In a silo more than 36 feet in depth it is not necessary to have a man to tramp the cut corn. If the surface is leveled two or three times a day while filling, the silage will pack sufficiently to keep. But there is one objection to doing this. If the cut corn is allowed to pile up in the form of a cone, the heavier parts will roll to the outside of the pile and the grain and leaves will not be evenly mixed.

Several devices have been invented for distributing the cut material in the silo, but few of them are successful. One of the most satisfactory distributers where a blower is used consists of two boards, 8 or 10 inches wide and about half as long as the diameter of the silo, nailed together at right angles to form a trough. A 12-inch board is nailed over one end of this trough, the other end being left open. For use, the trough is suspended from the roof with the open side downward and the closed end toward the center of the silo. The open end rests above the top of the blower pipe. As the cut material leaves the pipe it follows along this trough until it strikes the closed end; then it is scattered about the silo. If a little care is exercised in adjusting this device, it will give very good results.

PARTNERSHIP ARRANGEMENTS AMONG FARMERS.

The high cost of machinery for cutting silage and the difficulty in securing help prevent many farmers from building silos. It is highly important to be able to get an outfit when it is needed. An early frost or a spell of hot, dry weather may so affect the crop that it is necessary to fill the silo several days before the usual time. For this reason a man should own his cutter and engine, especially if enough silage is cut each year to warrant this outlay of capital. It is usually easier to hire an engine than it is a cutter. For this reason many buy the latter and depend on being able to rent the former when it is needed. The next best arrangement to owning an outfit individually is for two or three farmers in the same neighborhood to buy the necessary machinery in partnership.

The owners of farms Nos. 14, 17, and 26 bought a silage cutter together. At filling time each man furnishes two laborers and one team while the others are filling. By varying the seeding time in the spring they have been able to control the time of harvesting so that all three get their silos filled with corn in good condition.

O

995 Issu

U. S. DEPARTMENT OF AGRICULTU

FARMERS' BULLETIN 293.

USE OF FRUIT AS F(

BY

C. F. LANGWORTHY, Ph. D.,
In Charge of Nutrition Investigations, Office of Experiment Stat

PREPARED UNDER THE SUPERVISION OF THE OFFICE OF EXPERIMENT
A. C. TRUE, Director.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., April 11, 1

SIR: I have the honor to transmit herewith, and to recomme publication as Farmers' Bulletin. No. 293, an article on the fruit as food, prepared by C. F. Langworthy, in charge of nu investigations of this Office, in accordance with instructions by the Director.

The present bulletin is a revision and extension of an arti Doctor Langworthy bearing a similar title, which was publis the Yearbook of the Department for 1905, and constitutes a su of available data on the composition, food value, and place in t of fresh and preserved fruits of different sorts, particularly the of temperate regions which are commonly grown in the United In preparing the bulletin an extended study has been made literature of the subject, especially of the numerous investig reported by the agricultural experiment stations and the scattered articles in American and foreign journals. The p bulletin is therefore similar in scope and purpose to the popula lications which the Department has issued in the past summ available information on different food materials which enter into the diet of most American families.

Respectfully,

A. C. TRUE,
Dire

HON. JAMES WILSON,
Secretary of Agriculture.

USE OF FRUIT AS FOOD.

INTRODUCTION.

Edible fruits show the greatest range in form, color, and appe and are found in almost countless varieties; yet from the boi standpoint all our fruits are the seed-bearing portion of the The edible fruits of temperate regions fall into a few groups- fruits, like cherries and plums; pome fruits, like apples and grapes; and berries, like strawberries, blackberries, and cu There are several products, such as muskmelons, cantaloupe watermelons, sometimes classed as fruits and sometimes as vege which, of course, would not belong to any one of these groups. ical fruits are not so easily classified, though the citrus family (o: lemons, etc.) includes many of the more common sorts.

There are a few vegetable products which are not fruits botanical sense, but which by common consent are included class of food products since their place in the diet is the same most common of these products is rhubarb, and there are fe of fruit which the acid rhubarb stalk does not serve. Angelica which are candied and used for making cakes and confectione much less common, though the total amount used is large. certainly more natural to include preserved, candied, and cryst ginger root with candied pineapple, candied cumquats and products than with any other class of food materials, and ol ioned candied sweet flag root may also be mentioned in th nection.

WILD AND CULTIVATED FRUITS.

In an account of the first Virginia colony it is stated tl Indians ate wild mulberries, crab apples, and huckleberries, bu ing is said of their cultivating fruits, though they raised co other vegetables. Wild fruits have been part of the diet of tive man whenever obtainable, and no one can say with ce when wild varieties were first cultivated, but it must have bee in the history of the race, since such fruits as apples and peai been under cultivation so long that the varieties now grow: scarcely any resemblance to the very small, woody, inferior i the wild parent. As a country becomes more thickly settle and less reliance can be placed on wild fruits, and the market gε and fruit grower become of increasing importance. In the United States, strawberries, blackberries, and raspberries are examples of fruits which are still eaten both wild and cultivated, and cranberries have so recently come under cultivation that many persons still think of them as a wild fruit. Huckleberries and blueberries are practically unknown, except as they grow wild, though attempts are now being made to bring the blueberry to greater perfection under cultivation. Among little-known wild fruits elderberries and scarlet haws or thorn apples, to give them their New England name, may be mentioned. Both are used for jelly making to some extent and the former for other purposes also, but as yet neither is considered as of much importance.

It would be difficult to say why some fruits which are considered to be fairly palatable and equal to others which are generally eaten have obtained so little popularity. For instance, both wild and cultivated mulberries have long been known and prized by many, but are perhaps unknown to the majority of persons and very little used. In the same way the medlar, a fruit closely related to the apple and common enough in parts of Europe, is almost unknown in the United States, though it could be readily grown, if desired.

In some of our cultivated fruits, like the banana, seed is almost never found; in the case of others, for instance the orange, the seedless and seed-bearing varieties are both common; but in the majority of fruits seeds are present in greater or less abundance. It has been said that seedlessness is a result of long-continued cultivation, but it seems more probable that the seedless forms are due to the propagation and cultivation of natural sports without seeds. Seedless sports are by no means uncommon in wild fruits. Thus the native American persimmon is now and then found bearing seedless fruit, and such a form could be perpetuated by horticulturists, if need be. The seedless navel orange has been propagated in recent times from a seedless sport, and it seems very probable that bananas, though the wild forms are commonly full of seeds, were propagated from a seedless sport in times too remote for record. Indeed, it may be said that there is an almost universal tendency to cultivate and perpetuate varieties in which seeds are few in number or small in size, and quite naturally, since such fruits are more convenient to use and contain a higher proportion of nutritive material in a given bulk.

In general, it is true that size, yield, color, flavor, texture, and chemical composition are modified by cultivation.

The commercial fruit grower, of course, desires a fruit of good appearance, having satisfactory shipping and keeping qualities, and too often the consumer is satisfied to accept a product in which such qualities predominate. Discriminating purchasers, however, will insist on good flavor, texture, and cooking qualities as well, and such demands should be more often urged in order that quality may replace appearance as a standard in cultivating fruit for market.

MARKET CONDITIONS AND FRUIT SUPPLY.

The fruit market has been very greatly modified and extended by improved methods of transportation and storage. A man need not be very old to remember the time when, at least in the Northern States, bananas were a comparative rarity outside the large cities, and oranges and lemons, though common commodities, were rather high in price. In the summer there was an abundance of the common garden fruits, but in winter apples were practically the only sort which was at all plentiful. A few years have witnessed a great change, and now there is hardly a village so small that bananas and other southern fruits can not be purchased at reasonable prices. In Europe the situation is much the same. Such quantities of bananas are now taken to England and sold at such reasonable rates that they are sometimes spoken of there as the poor man's fruit. At the present time there are a number of fruits, such as avocados or "alligator pears," mangoes, and sapodillas, which are fairly well known in our large markets though seldom seen in the smaller towns. The enormous development of the fruit-growing industry in California and Florida, which includes the products of both temperate and warm regions, as well as the possibilities of supplying the northern markets with tropical fruits from Porto Rico and Hawaii, makes it probable that within a few years the avocado, the mango, and other tropical fruits will be as well known as the pomelo or the pineapple.

Improvements in transportation have also materially lengthened the season of many fruits, such as strawberries, which can not be stored for any considerable period. Florida and the Carolinas now send their berries to northern markets months before the home-grown crop can be expected and several weeks before that from tidewater Virginia or New Jersey is ripe. As an illustration of the effect of improved methods in shipping fruit, it may be mentioned that melons from the south of France, hothouse peaches from Belgium, and peaches, plums, and other fruits from South Africa are now sent to our American markets in winter. The introduction or origination of new varieties of fruits also prolongs the season. As an instance may be cited the Peen-to peach, a Chinese variety which can be successfully raised in Florida and Texas, and which is found in our northern markets in early spring, though at present at prices which clearly make it a luxury. Furthermore, improved methods of culture and transportation have extended the area planted to old and well-known varieties.

COLOR AND FLAVOR OF FRUITS.

Fruits, like leaves and flowers, owe their varied color to a number of chemical compounds, the green to chlorophyll (the characteristic coloring matter of green leaves), the yellow to xanthin bodies and other yellow pigments, and the blue and red to solutions in the cell sap of complex coloring matters which have in most cases been isolated and classified. Several coloring matters are often present in combination and give rise to the great variety of shades which different fruits present. In white fruits coloring matter is absent from the epidermis and the cells are said to be filled with air. As fruits develop, mature, and deteriorate, the coloring matters present undergo marked chemical changes, and color is one of the most common means of judging of ripeness.

Attractive color has a decided effect on market value, and the public demand varies greatly in different regions. Thus, a yellow or russet dessert apple is demanded in the French market, while in many parts of the United States the red apple has the preference. A faded, dull color is often an indication of staleness; strawberries and raspberries which have been kept too long have little of the brilliant color of freshly gathered fruit. That fruit colors in general are not very permanent is shown by the way the color deteriorates on long-continued cooking or fades when canned and preserved fruits are exposed to the light.

In preparing such fruits as plums, peaches, etc., for the table, the skin may be readily removed, without injury to the flavor by first immersing them for a short time in boiling hot water. A silver knife should always be used for paring apples, pears, and other fruits, as if a steel knife is used the acid of the fruit acts on the iron of the knife and frequently causes a black discoloration, and there is also very commonly a noticeable metallic flavor. If pared or cut fruit is exposed to the air, it rapidly turns dark in color, owing to the action of oxydases, as some of the ferments normally present in fruits are called, upon the tannin or other readily oxidizable bodies which are also normal fruit constituents.

In the same way the brown color of the bruised spots in apples is caused by oxidation by means of the oxydases present in the fruit of the tannin in the crushed cells. Such bruised portions contain a larger proportion of starch than the rest of the apple because the tannin hinders the transformation of starch into sugar.

In investigations carried on at the Oregon Agricultural Experiment Station with a view to preventing the discoloration of evaporated fruits and vegetables it was found that treating sliced apples with a weak solution of common salt (1 to 2 per cent) resulted in a product which was very bright and white and of better appearance than that obtained by the well-known domestic method of treatment with cold water. It seems probable that the Oregon method may find application in the household.

Fruits owe their flavor in considerable degree to the sugars and the malic, citric, and other acids which they contain, but the flavor which is so characteristic of different kinds is almost entirely due to ethereal bodies. The amount present is often too small for determination by the usual chemical methods. However, in many cases these flavor-giving bodies have been studied and their chemical nature is known.

The flavor of strawberries has been shown to be dependent in part at least upon the presence of a volatile oil with pronounced strawberry odor which is found in small proportions in the extracted fat of the dried berries. Recent German investigators [a] have identified the compound ethers which give bananas their characteristic flavor.

With the orange and other citrus fruits the oil found in the skin has a very characteristic odor and flavor which are always associated in our minds with the flavor of the fruit. Obviously, the small amount of these bodies of pronounced odor and flavor can not materially modify the nutritive value of fruits, but they are of great importance in considering the place of fruit in the diet, as they are very largely responsible for its attractiveness and palatability. There is no doubt that we all eat more readily the foods which please our palate than those which are of indifferent flavor, and there is every reason to believe that the foods which please are actually digested more easily than those which do not, since they stimulate a normal and abundant production of digestive juices.

COMPOSITION OF FRUITS.

Determining the proportion of water, protein, fat, carbohydrates (nitrogen-free extract and crude fiber), and ash in fruits as in other foods furnishes a convenient basis for judging of their relative food value. It is quite common for chemists to determine, instead of their proximate constituents, the proportions of the different nitrogenous bodies present, as well as the amounts of the different sugars, etc., which in the ordinary method of analysis are grouped with the other carbohydrates.

The more detailed analyses are of great interest and value for many reasons, but with our present knowledge it seems fair to assume that the various sugars and starches, for instance, have the same nutritive value, and so a knowledge of the total quantity of these bodies present gives very satisfactory data for estimating the food value of the group.[b] Very many analyses and studies of fruit and fruit products have been made by chemists of the agricultural experiment stations, as well as by the different Bureaus of the Department of Agriculture. Table 1 summarizes a large amount of such data and shows the composition of fresh, dried, and preserved fruits and fruit products, and for comparison the composition of a few other foods as well. In this table and the discussions which follow, attention has been given especially to the fruit of northern and temperate regions and no attempt has been made to summarize the considerable amount of data available regarding tropical fruits, except some which are grown in the United States or which are fairly well known at least in the larger markets. Special studies of tropical fruits have been made by the California and by the Maine experiment stations, and the Bureau of Chemistry[a] of this Department has reported an extended series of investigations of such fruits and the jams and preserves made from them.

---

[a] Deut. Essigindus., 1905, p. 81.

[b] An extended summary of the more detailed analyses of fruits and fruit products may be found in König's Chemie der menschlichen Nahrungs- und Genussmittel. Berlin, 1903, vol. 1, 4th ed., pp. 820–895.

Most of the fruits and fruit products included in the table are too well known to need description. Of those which are less familiar, the avocado or "alligator pear" is a green or purple fruit not unlike an eggplant in appearance. The portion eaten is the pulp which surrounds the single large seed. In texture it is soft and somewhat like butter, and to this quality it doubtless owes the name "midshipmen's butter," given to it in the days of sailing vessels. The avocado is eaten in a variety of ways, but is most commonly served as a salad. This fruit has a delicate almost nut-like flavor, and is every year becoming more popular. Earlier publications[b] of this Department have discussed the avocado at length and described its cultivation and uses.

The fruits of several sorts of cactus are very commonly eaten in Mexico and other regions where cactus is abundant, and are common though less well known in New Mexico and the Southwest. Under the name of prickly pear or Indian fig fresh cactus fruits, particularly the oblong, oval, yellowish or reddish fruits of *Opuntia ficus indica*, showing here and there characteristic tufts of fine spines or bristles, are occasionally seen at certain seasons of the year in large fruit shops. Cactus fruits may be used for jam making and in similar ways. A rather hard solid preserve or "cactus cheese," which may sometimes contain nuts, is a Mexican sweetmeat.

Many varieties of the guava, a very aromatic tropical and subtropical fruit, are grown in the warmer regions of the United States, and its uses are so varied that it is often said the guava occupies much the same place in cookery in the Tropics as the apple in northern regions. The fresh fruit is seldom seen outside the regions where it is grown, but guava jelly and guava paste are common commercial products, and have been popular ever since the days when the West India merchantmen brought these delicacies, preserved tamarinds, and oranges and lemons to our northern markets as well as such staple goods as sugar and molasses.

---

[a] U. S. Dept. Agr., Bureau of Chemistry Bul. 87.

[b] U. S. Dept. Agr., Bureau of Plant Industry Bul. 77; Farmers' Bul. 169.

The roselle or Jamaica sorrel is the fruit of a widely distributed tropical hibiscus which is grown extensively in California and Florida. The fruits somewhat resemble okra in form, are of a dark magenta color, and have an acid flavor much like that of cranberries. They are used for jams, jellies, etc.

The Surinam cherry is the fruit of a South American tropical shrub now grown to a limited extent in southern Florida and California. It is about the size and shape of an ordinary cherry, and owes its common English name to this fact. The fruit is bright red in color, and has a sharp but pleasant acid flavor. The Surinam cherry is used for jelly making, etc., but is seldom a commercial product.

The loquat, commonly though incorrectly called the Japan plum, is grown to a considerable extent in the southern United States. The small, yellowish, plum-like fruits are almost translucent when ripe, and are covered with a downy fuzz or bloom. The pulp is soft and tender and quite tart until fully ripe. The flavor is distinct and agreeable. Loquats are used both raw and cooked, and both fresh and preserved fruits are commercial products.

The sapodilla, a tropical fruit which thrives in regions like the warmer parts of Florida, suggests a good sized russet apple in appearance, but when broken open is quite different in character, as it contains a number of rather large flat brown seeds embodied in a tender brownish white pulp. The flavor is characteristic, and to some palates suggests a combination of a pleasant mild acid with caramel or brown sugar. The sapodilla is a not uncommon commercial fruit in large fruit shops.

Perhaps no fruit of the Tropics is more often discussed than the mango, some persons being exceedingly fond of this juicy aromatic fruit while others are as outspoken in their dislike. There are countless varieties of the mango, and many of them have a rank turpentine-like flavor, and are very fibrous. These qualities are not apparent, however, in the best varieties, which are of very delicate flavor and very palatable. The fruit is cooked in a variety of ways, being a staple article of diet in the Tropics, and is also eaten fresh. Some difficulty is experienced in shipping mangoes, as the flesh is very juicy and tender, but they are occasionally found in market at least as far north as Washington, D. C.

TABLE 1.—*Average composition of fruits and fruit products.*

Kind of fruit.	Refuse.	Edible portion.						
		Water.	Protein.	Ether extract.	Carbohydrates.		Ash.	Fuel value per pound.
					Nitrogen-free extract.	Crude fiber.		
FRESH FRUITS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Apples	25.0	84.6	0.4	0.5	13.0	1.2	0.3	290
Apricots	6.0	85.0	1.1	....	13.4		.5	270
Avocado	29.0	81.1	1.0	10.2	6.8		.9	512
Bananas	35.0	75.3	1.3	.6	21.0	1.0	.8	460
Blackberries	....	86.3	1.3	1.0	8.4	2.5	.5	270
Cactus fruit	....	79.2	1.4	1.3	11.7	3.7	2.7	375
Cherries	5.0	80.9	1.0	.8	16.5	.2	.6	365
Cranberries	....	88.9	.4	.6	8.4	1.5	.2	215
Currants	....	85.0	1.5	....	12.8		.7	265
Currants (black)[a]	....	79.0	[b].5	[b].3	13.1	[a]6.1	1.0	370
Figs	....	79.1	1.5	....	18.8		.6	380
Gooseberries[a]	....	85.6	[b]1.0	....	[c]13.1		.3	255
Grapes	25.0	77.4	1.3	1.6	14.9	4.3	.5	450
Guava[a]	....	82.9	1.3	.7	8.0	6.6	.5	315
Huckleberries	....	81.9	.6	.6	16.6		.3	345
Lemons	30.0	89.3	1.0	.7	7.4	1.1	.5	205
Loquat	....	77.9	.2	....	20.2	.6	1.1	395
Mango[a]	[b]40.0	87.4	.6	.4	9.9	1.2	.5	220
Medlar[a]	....	74.6	.5	.3	16.5	7.5	.6	455
Mulberry[a]	....	84.7	.4	....	14.3		.6	280
Muskmelons	50.0	89.5	.6	....	7.2	2.1	.6	185
Nectarines	6.6	82.9	.6	....	15.9		.6	305
Olives	17.9	67.0	2.5	17.1	5.7	3.3	4.4	407
Oranges	27.0	86.9	.8	.2	11.6		.5	240
Peaches	18.0	89.4	.7	.1	5.8	3.6	.4	190
Pears	10.0	80.9	1.0	.5	15.7	1.5	.4	163
Persimmons	[b]25.0	66.1	.8	.7	29.7	1.8	.9	630
Persimmons (Japanese)	24.0	80.2	1.4	.6	15.1	2.1	.6	174
Pineapples	40.0	89.3	.4	.3	9.3	.4	.3	200
Plums	5.0	78.4	1.0	....	20.1		.5	395
Pomegranates	[b]30.0	76.8	1.5	1.6	16.8	2.7	.6	460
Prunes	5.8	79.6	.9	....	18.9		.6	370
Raspberries (red)	....	85.8	1.0	....	9.7	2.9	.6	255
Raspberries (black)	....	84.1	1.7	1.0	12.6		.6	310
Red bilberry	....	89.6	.1	[b].3	3.8	[b]6.0	.2	190
Rhubarb stalks	40.0	94.4	.6	.7	2.5	1.1	.7	105
Roselle calyx	....	86.5	2.1	.3	10.3		.8	235
Roselle pod	....	84.0	1.7	1.0	12.2		1.1	290
Sapodilla[a]	[b]40.0	77.9	.5	1.6	16.6	2.8	.6	425
Scarlet haws	20.0	75.8	2.0	.7	18.6	2.1	.8	212
Strawberries	5.0	90.4	1.0	.6	6.0	1.4	.6	180
Surinam cherry	....	85.0	.4	....	13.9		.7	280
Watermelons	59.4	92.4	.4	.2	6.7		.3	140
Whortleberries	....	82.4	.7	3.0	10.3	3.2	.4	390
DRIED FRUITS.								
Apples	....	26.1	1.6	2.2	62.0	6.1	2.0	1,350
Apricots	....	29.4	4.7	1.0	62.5		2.4	1,290
Bananas[a]	....	29.2	5.3	2.3	55.8	2.1	5.3	1,240
Banana flour	....	9.7	3.1	.5	83.4	.7	2.6	1,610
Citrons	....	19.0	.5	1.5	78.1		.9	1,525
Dates	10.0	15.4	2.1	2.8	74.6	3.8	1.3	1,615
Figs	....	18.8	4.3	.3	68.0	6.2	2.4	1,475
Pears	....	16.5	2.8	5.4	66.0	6.9	2.4	1,635
Prunes	15.0	22.3	2.1	....	71.2	2.1	2.3	1,400
Raisins	10.0	14.6	2.6	3.3	73.6	2.5	3.4	1,605
Raspberries	....	8.1	7.3	1.8	80.2		2.6	1,705
St. John's bread	....	[b]17.3	5.7	1.1	67.0	6.4	2.5	1,480
Zante currants (English currants)	....	17.2	2.4	1.7	71.2	3.0	4.5	1,495
CANNED FRUITS, PRESERVES, JELLIES, ETC.								
Crab apples (canned)	....	42.4	.3	2.4	54.4		.5	1,120
Apple sauce	....	61.1	.2	.8	37.2		.7	730
Apricots (canned)	....	81.4	.9	....	17.3		.4	340
Apricot sauce	....	45.2	1.9	1.3	48.8		2.8	1,000
Blackberries (canned)	....	40.0	.8	2.1	56.4		.7	1,150
Blueberries (canned)	....	85.6	.6	.6	12.8		.4	275
Cherries (canned)	....	77.2	1.1	.1	21.1		.5	415
Cherry jelly	....	21.0	1.1	....	77.2		.7	1,455

[a] European analysis. [b] Assumed. [c] Including 3.5 per cent skin and seeds.

TABLE 1.—*Average composition of fruits and fruit products*—Continued.

Kind of fruit.	Refuse.	Edible portion.						
		Water.	Protein.	Ether extract.	Carbohydrates.		Ash.	Fuel value per pound.
					Nitrogen-free extract.	Crude fiber.		
CANNED FRUITS, PRESERVES, JELLIES, ETC.—continued.								
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Figs, stewed		56.5	1.2	0.3	40.9		1.1	785
Grape butter		36.7	1.2	.1	58.5		3.5	1,115
Olives, green, pickled	27.0	58.0	1.1	27.6	11.6		1.7	1,400
Olives, ripe, pickled	19.0	64.7	1.7	25.9	4.3		3.4	1,205
Orange marmalade		14.5	.6	.1	84.5		.3	1,585
Peaches (canned		88.1	.7	.1	10.8		.3	220
Pears (canned)		81.1	.3	.3	18.0		.3	355
Pineapples (canned)		61.8	.4	.7	36.4		.7	715
Prunes, stewed		76.6	.5	.1	22.3		.5	430
Strawberries, stewed		74.8	.7		24.0		.5	460
Angelica stalks (candied)		10.4	.1	.1	87.3	1.5	.6	1,550
Apricots (candied)		14.4	.7	.1	83.0	1.1	.7	1,445
Cherries (candied)		12.1	.5	.2	86.1	.5	.6	1,455
Citron (candied)		18.2	.1	.1	77.6	1.0	3.0	1,380
Ginger root (candied)		12.3	.3	.2	86.1	.7	.4	1,520
FRUIT PRODUCTS.								
Olive oil				100.0				4,035
Raspberry juice		49.3	.5		[a] 49.9		.3	935
Unfermented grape juice		92.2	.2	[b] .5	6.9		.2	150
OTHER FOODS FOR COMPARISON.								
Cabbage	15.0	91.5	1.6	.3	4.5	1.1	1.0	145
Potatoes	20.0	78.3	2.2	.1	18.0	.4	1.0	385
Wheat flour, high grade		12.0	11.4	1.0	74.8	.3	.5	1,650
Corn meal, bolted		12.5	9.2	1.9	74.4	1.0	1.0	1,655
White bread		35.3	9.2	1.3	52.6	.5	.5	1,215
Beans, dried		12.6	22.5	1.8	55.2	4.4	3.5	1,605
Honey		18.2	.4		81.2		.2	1,520
Sugar, granulated					100.0			1,860
Butter		11.0	1.0	85.0			3.0	3,605

[a] Probably contained added sugar.

[b] European analysis.

Most fruits, like other classes of foods, contain more or less material, such as pits, skin, etc., which is inedible. When such portions are removed a larger or smaller part of the edible material is almost always of necessity removed also, and is spoken of as "waste." In reporting analyses the amounts of inedible material and waste are grouped together under the heading "refuse." As may be seen from the above table, the proportion of refuse in fruits varies within rather wide limits. Thus, of pears it constitutes on an average 10 per cent of the total fruit, peaches 18 per cent, apples and grapes 25 per cent, and bananas 35 per cent, while in the case of raspberries and blackberries there is no refuse and the whole fruit can be eaten. The composition of some fresh and dried fruits is shown graphically in figure 1.

The analytical data quoted above show that fresh fruits are in general dilute foods—that is, the proportion of water which they contain is large, compared with the total amount of nutritive material. It has been suggested that fruits containing 80 per cent or more of water be classed as flavor fruits and those with less than 80 per cent as food fruits. As may be seen from the table (p. 14), such fruits as strawberries, blackberries, and raspberries would be included in the first class, and fresh figs, bananas, grapes, etc., in the second. In dried fruits which have been concentrated by evaporation the percentage of nutrients is very much higher than in fresh fruits. Some preserved fruits also possess a comparatively high nutritive value, owing to the evaporation of water by the heat of cooking or to the addition of

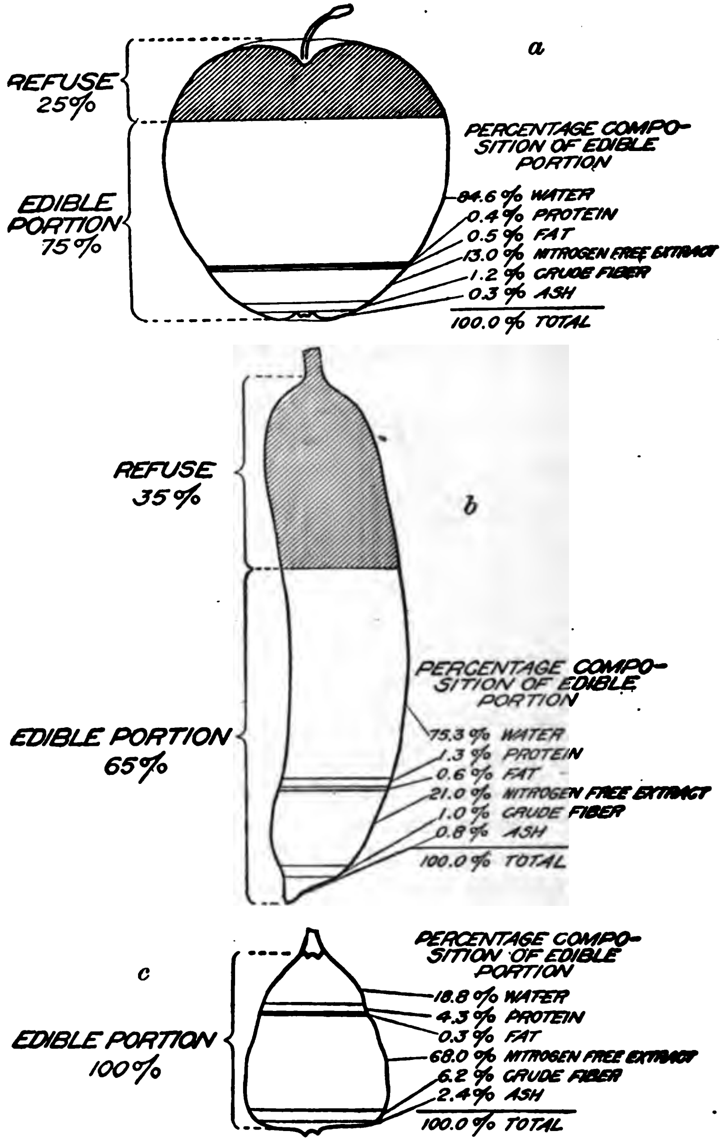


FIG. 1.—Composition of apple (*a*), banana (*b*), and dried fig (*c*).

sugar, or to both factors. Candied fruits, such as cherries and apricots, which are included in the table, may be looked upon as typical examples of this class of fruit products. As regards composition, the water content is low and the carbohydrates and consequently the energy value is very high, owing to the added sugar.

Olives and the avocado are remarkable for the large percentage of fat which they contain, but in general it may be said that this constituent is present in very small proportion in fresh fruits. In the case of the apple, pear, etc., it seems probable that the small amount of fat obtained in chemical analysis consists of the coloring matter contained in the fruit or of wax found in the skin. That the amount of wax may be considerable is evident when we recall the fact that fruit wax is collected from bay berries and other fruits in quantities sufficient for candle making and other purposes. That common fruits actually contain fat, though it is not generally associated with them, is shown by a recently published study of the fat of woods strawberries. The dried berries when extracted yielded a small amount of oil, cloudy at ordinary temperatures, but clear when heated, and much like linseed oil in its properties.

In the majority of fruits and fruit products the carbohydrates are the food constituents most abundantly represented. The figures in the table show that the proportion of nitrogen-free extract varies greatly, being lowest in the fresh and highest in the dried and preserved fruits. It is interesting to consider also the values which have been reported for some of the constituents not shown in the table, but included in the group "nitrogen-free extract." In seeds which are commonly eaten, such as the cereal grains, and beans, peas, and other legumes, the nitrogen-free extract is quite largely made up of starches. In fruits, however, sugars and the so-called pectin bodies, with very often more or less starch, make up the group. The principal sugars in fruit are cane sugar, grape sugar (glucose), and fruit sugar (levulose), the last two being usually present together in equal quantity and designated invert sugar or reducing sugar. The stage of growth and the degree of ripeness have a very marked effect on the kind and amount of sugar, and it is therefore difficult to give average figures for the quantities present which will be fairly representative. An idea of the range in the sugar content of ripe fruits may be gathered from figures quoted from a summary[a] published several years ago. According to these data, invert sugar ranged from 2 per cent in round numbers in large early apricots to 15 per cent in grapes and a variety of sweet cherries. A number of fruits (strawberries, gooseberries, raspberries, and apples) contained about half the latter quantity. The cane sugar ranged from less than 1 per cent in lemons to 14 per cent in a variety of plums. Bananas also contained a fairly high percentage, namely, 11 per cent.

---

[a] Lippman: Chemie der Zuckerarten, 1895, 3d ed., pp. 493, 591; 1904, 4th ed., pp. 200, 794.

Fruit sugar rarely occurs unaccompanied by grape sugar, but has been thus reported in the mango and in amounts large in proportion to the grape sugar in sweet apples and sweet pears and a number of varieties of grapes. In the case of grape sugar large amounts—18 to 30 per cent—have been reported in juice of different sorts of grapes, while in dried fruits the values are even higher, 32 per cent having been found in prunes, 54 per cent in Zante or "English" currants, which are of course a small seedless grape, 61 per cent in raisins, 48 per cent in figs, and 66 per cent in dates.

The acid in fruits, which in proximate analyses is not usually determined separately, varies within rather wide limits, 1 to 2 per cent being reported on an average in such fruits as apples, pears, plums, strawberries, etc., and as high as 7 per cent or more in lemon juice. It often happens that of two fruits with the same acid content one has a much sourer taste than the other, because the acid is not so much masked by sugar.

Fruits contain a comparatively small amount of mineral matter—less than 1 per cent on an average – consisting quite largely of potassium salts, with a little phosphoric acid, iron, lime, etc.

As a class, it is apparent that fresh fruits are directly comparable with green vegetables and root crops rather than with more concentrated foods, such as flour or meal. The dried and some of the preserved fruits, which are more concentrated than the fresh, compare favorably with bread, dried beans, and similar foods on the basis of total food material present. There is this difference, however, that the cereals and dried legumes contain fairly large proportions of protein, while the quantity present in fruits is always small. In other words, fruits—fresh, dried, and preserved—are sources of energy rather than of tissue-forming material.

Grape juice and other freshly expressed juices are pleasant and wholesome beverages. They are commonly preserved for winter use at home as well as on a commercial scale by sterilizing in bottles. The fruit juices are dilute foods, as the figures given for grape juice in Table 1 indicate. Fruit sirups made by adding sugar to the juice are extensively used in the household and in other ways. The food value of such articles is, of course, considerably increased by the sugar which they contain.

In connection with the subject of fruit juices and sirups, it may be of interest to mention the Turkish preparation, which is made by evaporating grape juice until it is of the consistency of molasses, then thickening with flour or starch, and spreading it out to dry in the sun in thin sheets. This product is not unlike the peach leather, which is an old-fashioned domestic product still made to some extent in much the same way in the southern United States by drying crushed peach pulp on platters in an oven. Plum leather is also sometimes made in the same way. After soaking in water for some hours peach leather is ready for use on the table or for making puddings, etc. Another Turkish preparation called sujuk or rojik is made by stringing walnuts on pieces of stout twine about a yard long and immersing them in a mixture of grape molasses and flour. After receiving a coating about one-fourth of an inch thick they are withdrawn and hung up to dry, and may then be preserved in jars in good condition for a few months. Sujuk is said to be an excellent article of food and palatable. Sometimes wheat grits are used to thicken the grape sirup, and the nut and sirup mixture is made in the form of cakes about one-half an inch thick when dried.

Vinegar which contains about 3 per cent of extractive material and 0.5 per cent ash, in addition to 6 per cent acetic acid and over 90 per cent water, is one of the oldest fruit products and also one of the oldest and most common condiments and household preservatives. It owes its use in the diet to flavor and other qualities rather than to the very small amount of nutritive material which it may contain. Honey vinegar,[a] malt vinegar, etc., are well known, but vinegar made from fruit juice is far more common. By fermentation the sugar in the original material is converted into acetic acid, and to this the vinegar largely owes its flavor, though the salts and other materials originally present in the fruit juice have an effect upon this quality. Vinegar made from apple juice—that, is cider vinegar[b]—has always had a reputation for good quality, though other fruit juices are of considerable importance in domestic vinegar making, banana vinegar being one of the sorts which is rather favorably known in regions where this fruit is grown. The acid juice of lemons and limes is used like vinegar as a condiment, and many persons consider that lemon juice is more delicate. It is sometimes claimed that it is more wholesome also, but this seems hardly more than a matter of opinion, as there is no reason to suppose that the small amounts of vinegar ordinarily used are in any way harmful.

Verjuice, the expressed acid juice of green apples, crab apples, or other unripe fruit, was formerly used as a condiment and was greatly prized. It has survived in modern cookery in a limited way and may occasionally serve a useful purpose when lemon juice is not readily obtainable.

---

[a] For description and method of making, see U. S. Dept. Agr., Farmers' Bul. 276.

[b] Vinegar making and related questions are taken up in U. S. Dept. Agr., Farmers' Bul. 233.

RIPENING AND ITS EFFECT ON COMPOSITION.

As fruits grow to their full size and ripen they undergo marked changes in chemical composition with respect both to the total and to the relative amount of the different chemical bodies present. When stored after gathering, the changes continue, some fruits improving on storage and others deteriorating very rapidly. In general, ripe fruits are less acid than green and contain less starch, woody material, crude fiber, and the carbohydrates commonly referred to as pectin bodies (see p. 29), and correspondingly larger amounts of the different sugars.

Fruits contain oxydases and other ferments, and these are believed to play a very important part in the chemical changes which accompany growth and maturity. Many diverse views have been expressed regarding the exact nature and extent of the processes involved and the compounds formed in ripening fruit. The question as a whole has been a favorite one with chemists, and the agricultural experiment stations have made a number of important contributions to the subject. One of the most recent and valuable contributions, both from a bibliographical and from a chemical standpoint, is the series of investigations published by Bigelow [a] and his associates, of the Bureau of Chemistry of the Department of Agriculture, on the ripening of winter and summer apples and of peaches. With winter apples it was found that the starch increases from early summer until the maximum is reached in midsummer and then decreases and finally disappears. The malic acid content decreases from early summer until maturity, while cane sugar and invert sugar increases.

In the case of peaches, as the fruit develops from early summer to ripeness the proportion of flesh increases and the pit decreases. During this period the weight of reducing sugars increases about eight times and that of cane sugar or sucrose and acids considerably more than this. An increase is also noted with the various forms of nitrogenous substances. Throughout the whole period of growth the proportion of solids to water in the flesh of the peach remains fairly constant. The pit, on the other hand, becomes harder and the percentage of water in it decreases as growth progresses. It is interesting to note that throughout the whole period of growth no appreciable amount of starch is found in the peach. Between the condition known as market ripeness and full ripeness considerable growth takes place in the peach, there being an increase in both water and solid matter and in reducing sugar and cane sugar. A German investigator [b] found that when black currants were picked when slightly green and kept for a few days there was an increase in sugar and a decrease in the acid content. The changes which take place in gooseberries do not appear to be of the same character. Picked when green, they contain 3.9 per cent sugar and 27.2 per cent acid. When stored at a cool temperature for six days they had taken on the dark color of ripe berries and contained somewhat smaller proportions of both sugar and acid.

---

[a] U. S. Dept. Agr., Bureau of Chemistry Buls. 94 and 97.

[b] Landw. Jahrb. Schweiz., 19 (1905), p. 600.

A knowledge of the changes which accompany the growth, ripening, and storage of fruits is very important commercially as well as from the housekeeper's standpoint. For instance, in cider making it is desirable that the fruit should be used when the sugar content is high, as the quality of cider and vinegar is largely determined by the amount of sugar present. As every housewife knows, underripe fruit—that is, fruit which still contains the so-called pectin bodies rather than the sugars and other carbohydrates characteristic of fully ripened fruit—is the most satisfactory for jelly making. (See p. 29.) In the case of bananas the underripe fruit, rich in starch, is best for cooking, and the very ripe fruit, in which the starch has been changed into sugar, for use uncooked. It is not unlikely that failure to recognize this distinction is responsible for the digestive disturbance which many persons experience when bananas are eaten, as the raw, underripe, starchy fruits are generally conceded to be difficult of digestion. The underripe bananas, when dried, sliced, and ground, yield a flour or meal rich in starch, while the riper fruit with the higher sugar content, sliced and dried, is very sweet and not unlike figs in flavor and composition.

WAYS OF SERVING FRUIT.

As regards the way in which they are served fruits range from the muskmelon, watermelon, and avocado, almost never cooked, to cranberries and the ordinary varieties of quince, which are not eaten raw. The methods of preparation are quite varied, including drying or evaporating, and baking, boiling, and stewing, while quantities of fruit are used in puddings, pies, and other dishes, and for the preparation of jams, jellies, and preserves. Fruit juices are used for beverages, and both fruits and the juices are very commonly prepared for the table by freezing, fruit ices being considered as among the most appetizing desserts. Some fruits, notably the green and the ripe olive and less generally the lime, are prepared for the table by pickling in brine.

Even a casual examination of cookery books and the periodical literature devoted to such topics shows that the ways in which fruits and fruit products can be cooked and served are practically endless. The housewife who desires to vary her menu by the use of more fruit and fruit dishes can do so very readily by consulting such sources of information.

The temperature at which fresh fruits are eaten is largely a matter of fashion or individual taste. With the increased use of ice in our homes during recent years it has become a very common custom to serve fruits colder than was formerly the case. Cool or even cold fruits are very refreshing and many prefer them served thus. There are others, however, who maintain that overchilling lessens the delicate flavor and accentuates the acid taste. They insist that the fruits gathered in the cool of the day and stored in a cool but not a cold place are at their best. Still others find them sweetest and most palatable when brought from the garden warmed by the sun.

PLACE OF FRUIT IN THE DIET.

In most families fruits are commonly thought of as a food accessory, and are prized for their pleasant flavor or for supposed hygienic reasons rather than for their food value; yet a study of available figures shows that they constitute a by no means unimportant part of the diet, since they supply, on the basis of recent statistics, 4.4 per cent of the total food and 3.7 per cent of the total carbohydrates of the average American diet (see also p. 36). With a view to learning something more definite regarding the possibilities of fruits as sources of nutrients, the relative cost of nutrients supplied by fruits and other foods, the digestibility of a fruit diet as compared with an ordinary mixed diet, and related questions, extended investigations were undertaken at the California Agricultural Experiment Station by Prof. M. E. Jaffa, the work as a whole being carried on in cooperation with the nutrition investigations of the Office of Experiment Stations. In the first series reported six dietary studies were made with fruitarians—two women and four children who had lived on a fruit and nut diet for several years. The dietary studies covered from twenty to twenty-eight days, and the daily food consisted of different combinations of fruits and nuts, of which the following day's ration may serve as a sample: 475 grams apples, 110 grams bananas, 850 grams oranges, 5 grams dates, 2 grams honey, 10 grams olive oil, 55 grams almonds, 70 grams pine nuts, and 50 grams walnuts.

The later studies were made with one of the women and two of the children included in the first group, and in addition with two elderly men who had been vegetarians for years and had limited their diet almost exclusively to fruits and nuts, and with two young men, university students, who were accustomed to the ordinary diet, though one of them had experimented with a vegetarian and fruitarian diet for some time. The students and one of the elderly men ate three meals a day at the usual hours. The others ate but twice, the first meal being taken between 10 and 11 o'clock in the morning and the second between 5 and 6 o'clock in the afternoon. As before, the diet included a large assortment of fresh fruits, with considerable quantities of dried fruits and nuts, and some honey and olive oil. In a few cases small quantities of other foods were also eaten.

Considering these studies as a whole, the diet of the women and children furnished from 32 to 43 grams of protein and 1,190 to 1,430 calories of energy per day, the cost ranging from 15.7 to 27.5 cents. It is the usual custom to discuss dietary studies on the basis of the amounts eaten per man per day, and the results obtained with these women and children, when recalculated to this basis, showed a range of 47 to 80 grams of protein and 1,850 to 2,805 calories of energy, the cost of the daily food ranging from 21 to 55 cents per man per day. In the studies with the young and the old men the protein supplied by the daily diet ranged from 40 to 85 grams and the energy from 1,712 to 3,305 calories, the average being 62 grams protein and 2,493 calories, the cost ranging from 18.1 to 47 cents per person per day. These amounts are considerably smaller than have been found on an average with families living in many different regions of the United States and under a variety of conditions, as is shown by the fact that with 52 families in comfortable circumstances the average protein in the daily diet was 103 grams and the average energy 3,500 calories. On the other hand, in many of the dietary studies made under the auspices of the Office of Experiment Stations it has been found that persons living on a mixed diet have obtained amounts directly comparable with those supplied by the fruitarian diet. Thus, at the North Dakota Agricultural College several years ago a dietary study showed that the food consumed per man per day by a group of students furnished 64 grams protein and 2,579 calories and at Lake Erie College 68 grams protein and 2,610 calories, calculated on a uniform basis per man per day.

In a recent investigation carried on at Harvard it was found that the diet of nine students who lived at the college commons and, from necessity or choice, endeavored to live cheaply supplied, on an average, 89 grams protein and 3,068 calories. In this case the average cost was 39.9 cents per day and at the North Dakota and the Lake Erie colleges 13 and 18 cents, respectively. It will thus be seen that in the California investigations the fruit and nut diet supplied the subjects with amounts of protein and energy which are directly comparable with those obtained by many other persons from a mixed diet, though in general the quantities were smaller than are supplied by the diet of the average family. It should be said that the persons living on a fruit and nut diet apparently maintained their normal health and strength, and it is only fair to conclude that if, for any reason, such a course seems desirable it is perfectly possible to select a diet made up of fruits and nuts which, for long periods at any rate, will supply the body with the requisite protein and energy, as was shown by a detailed study of the results of the California experiments. In such a diet nuts were the principal sources of protein and nuts, olives, or the expressed olive oil the chief source of fat, while fruits, fresh and dried, supplied the bulk of the carbohydrates.

As regards cost, it will be seen that there was a considerable range with the fruitarian diet, the amount expended per person per day being in some cases quite low and in others quite high. On the whole, the range did not differ greatly from that observed in many instances on an ordinary mixed diet.

It would seem from the recorded data that it is more difficult for the subjects to obtain the requisite amount of protein when on a limited diet of one kind of nut combined with fruits than it is when they are unrestricted and eat a variety of both fruits and nuts. In nearly all cases where the diet was limited to combinations of one or two fruits with one kind of nuts the subjects complained of a constant craving for some other food, such as green vegetables or cereals, and in these cases it was found that the coefficients of digestibility were lower than in those tests in which some vegetable or cereal was eaten, which made the diet more appetizing. The addition of a small amount of some cereal food to the diet markedly increased its protein and energy value.

It would be going too far to conclude on the basis of the California investigations that a fruitarian diet in general is equal or superior to the ordinary diet, and indeed the study of this question was not a part of the investigation. Before such a conclusion could be drawn it would be necessary to make investigations extending over a long period of years and with a variety of subjects, and which would take into account resistance to disease and other unfavorable conditions, body development, the health and condition of the offspring of persons living for years on such a diet, and other similar questions. It seems fair to say, however, that at the present time the consensus of opinion of well-informed physiologists is that the ordinary mixed diet is most convenient and satisfactory for the average individual. It is equally clear from the investigations reported that fruits and nuts should not be looked upon simply as food accessories, but should be considered a fairly economical source of nutritive material. It must be remembered, too, that the use of fruits, fresh and preserved, often makes palatable an otherwise rather tasteless meal. Jam with our bread is a reasonable combination, the highly flavored fruit product whetting the appetite for the needed quantity of rather flavorless bread.

DIGESTIBILITY OF FRUIT.

In addition to the dietary studies, a large number of digestion experiments were made at the California Experiment Station for the purpose of learning how thoroughly a diet made up of various combinations of fruits and nuts was assimilated. In such an experiment covering 10 days, made with a child 7 years old, on an average 82 per cent of the protein, 87 per cent of the fat, 96 per cent of the nitrogen-free extract (sugar, starches, etc.), 80 per cent of the crude fiber, and 54 per cent of the ash of the food eaten were digested, and 87 per cent of the energy of the diet was available to the body. In 30 experiments with men, 75 per cent of the protein, 86 per cent of the fat, 95 per cent of the nitrogen-free extract, 79 per cent of the crude fiber, and 55 per cent of the ash of the fruit and nut diet were digested, and 86 per cent of the energy was available. These values are comparable with those obtained from an ordinary mixed diet, as is shown by the fact that in 93 experiments with young men 93 per cent of the protein, 95 per cent of the fat, and 98 per cent of the total carbohydrates supplied were assimilated. The average coefficients of digestibility which have been calculated for fruits in connection with the nutrition investigations carried on under the auspices of the Office of Experiment Stations are protein 85 per cent, fat 90 per cent, and carbohydrates 90 per cent, and those for fresh vegetables, protein 83 per cent, fat 90 per cent, and carbohydrates 95 per cent.

The feces excreted per person per day on the fruit and nut diet in the California experiments were less in amount than has been the case in some experiments with a mixed diet or a ration of bread and milk. This is contrary to what has been commonly found with a vegetarian diet made up of bread and other cereal foods, garden vegetables, etc., and containing little if any fruit or nuts. The percentage of so-called metabolic nitrogen in the feces from the fruit and nut diet did not exceed that reported by other investigators in tests with a bread and milk diet. In other words, if the amount of metabolic products can be looked upon as a measure of the work of digestion, no more effort is required to digest the fruit and nuts than is needed for bread and milk. Although, as Professor Jaffa points out, it is undoubtedly advisable to wait until more data have been obtained before making definite statements regarding the digestibility of fruits and nuts, enough has been done to show that they are almost completely digested and have a higher nutritive value than is popularly attributed to them. In view of this it is certainly an error to regard fruit as something of value only for its pleasant flavor or for its hygienic or medicinal properties, or to consider nuts simply as an accessory to an already hearty meal. As shown by the composition and digestibility of both fruit and nuts, they can be favorably compared with other and more common food.

So far as can be learned, comparatively few investigations have been made to ascertain the digestibility of particular fruits, raw or cooked. In a series of investigations by Bryant and Milner the digestibility of apple sauce was determined when eaten with a simple basal ration. The coefficients of digestibility for apple sauce alone were calculated in the usual way and were, protein 28 per cent, nitrogen-free extract 99.6 per cent, crude fiber 96 per cent, and ash 100 per cent, while all the energy supplied by the apple sauce was considered to be available to the body. The coefficient of digestibility of protein is low, but, as the authors pointed out, the total amount of this constituent present was so small that it may be disregarded. This investigation, like those at the California Experiment Station, indicates that the fruit carbohydrates (sugar, starches, etc.), that is, the principal nutritive materials which fruits supply, are very thoroughly assimilated.

Few studies seem to have been made to determine the ease or rapidity of digestion of different fruits in the stomach, but a comparison of available data indicates that fruits compare favorably with other common foods as regards stomach digestion. Apparently it is fair to say that stomach digestion is influenced by the nature of the fruit and its stage of ripeness. Beaumont states that mellow sour apples eaten uncooked require 2 hours for digestion in the stomach and mellow sweet apples 1.5 hours. Another observer notes that about 5 ounces of raw ripe apple requires 3 hours and 10 minutes for digestion in the stomach, but states that if the fruit is unripe, and consequently contains a high proportion of cellulose, a much longer time may be required.

Little is definitely known regarding the relative digestion and absorption of fruits in the intestine, but experiments indicate that as a class ripe fruits are quite thoroughly digested, and it is evident that, generally speaking, fruits, like other foods, usually remain in the intestinal tract long enough for the body to absorb the nutritive material present, and that therefore the rate of intestinal digestion would not be a matter of special importance.

RELATIVE ECONOMY OF FRUITS AND OTHER FOODS.

In connection with his studies of the comparative value of fruits, Professor Jaffa summarizes data regarding the cost of nutrients and energy supplied by fruits as compared with some other foods at certain values per pound. Some of his data follow.

Table 2.—*Comparative cost of total nutrients and energy in fruits and other food materials at certain average prices.*

Kind of food material.	Price per pound.	Cost of 1 pound protein.	Cost of 1,000 calories energy.	Amounts for 10 cents.				
				Total weight of food materials.	Protein.	Fat.	Carbohydrates.	Energy.
FRESH FRUITS.	*Cents.*	*Dolls.*	*Cents.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Calories.*
Apples	1.5	5.00	7.3	6.67	0.02	0.02	0.72	1,467
Bananas	7.0	8.75	23.3	1.43	.01	....	.21	429
Grapes	4.0	4.00	11.9	2.50	.03	.03	.36	837
Oranges	6.0	10.00	35.2	1.67	.01	....	.14	284
Peaches	4.0	8.00	25.1	2.50	.01	....	.19	398
Pears	3.0	6.00	11.5	3.33	.02	.01	.42	866
Plums	3.0	3.33	8.1	3.33	.03	....	.64	1,232
Watermelons	1.5	7.50	25.0	6.67	.01	....	.18	400
Blackberries	7.0	5.38	25.9	1.43	.02	.01	.16	386
Cranberries	5.0	12.50	23.3	2.00	.01	.01	.20	430
Currants	5.0	3.33	18.9	2.00	.03	....	.26	530
Raspberries	7.0	7.00	27.4	1.43	.01	....	.18	365
Strawberries	7.0	7.78	40.0	1.43	.01	.01	.10	250
DRIED FRUITS.								
Apples	12.0	7.50	8.9	.83	.01	.02	.55	1,121
Dates	10.0	5.26	6.9	1.00	.02	.03	.71	1,450
Figs	15.0	3.50	10.2	.67	.03	....	.50	988
Prunes	10.0	5.56	8.4	1.00	.02	....	.62	1,190
Raisins	10.0	4.35	6.9	1.00	.02	.03	.69	1,445
JAMS, PRESERVES, ETC.								
Apple preserves	16.0	91.43	13.8	.62	....	....	.39	727
Apple butter	5.0	10.00	5.6	2.00	.01	....	.94	1,780
Currant and raspberry jam	16.0	26.66	12.8	.62	....	....	.42	781
Gooseberry jam	16.0	32.00	13.2	.62	....	....	.40	752
Orange marmalade	16.0	26.66	10.1	.62	....	....	.52	983
Prune sauce	16.0	32.00	37.2	.62	....	....	.14	267
Strawberry preserves	16.0	26.67	12.0	.62	....	....	.44	833
Apple jelly	16.0	53.33	12.2	.62	....	....	.43	812
Currant jelly	16.0	40.00	13.4	.62	....	....	.40	744
Guava jelly	16.0	53.33	10.5	.62	....	....	.51	952
Quince jelly	16.0	80.00	13.3	.62	....	....	.40	750
Apricots, canned	16.0	17.78	47.1	.62	.01	....	.11	211
Pears, canned	16.0	53.33	45.5	.62	....	....	.11	220
Peaches, canned	16.0	20.00	53.2	.62	....	....	.09	188
Grape juice	20.0	83.33	128.2	.50	....	....	.04	78
OTHER FOODS FOR COMPARISON.								
Porterhouse steak	25.0	1.31	22.5	.40	.07	.07	....	444
Leg mutton, hind	20.0	1.30	22.2	.50	.07	.07	....	445
Whole milk	3.5	1.06	10.5	2.86	.09	.11	.14	925
Skim milk	2.0	.59	11.8	5.00	.17	.02	.26	850
Wheat flour, patent roller process, high grade and medium	2.5	.22	1.5	4.00	.46	.04	3.00	6,600
White bread	5.0	.54	4.2	2.00	.18	.03	1.06	2,430
Rye bread	5.0	.56	4.3	2.00	.18	.01	1.06	2,360
Sugar	6.0	....	3.2	1.67	....	....	1.67	3,106
Candy	20.0	....	11.2	.50	....	....	.48	892
Beans, dried	5.0	.22	3.1	2.00	.45	.03	1.19	3,210
Celery	5.0	5.56	71.4	2.00	.02	....	.05	140
Potatoes, 90 cents per bushel	1.5	.83	4.8	6.67	.12	.01	.98	2,068

From the data in the foregoing table it appears that fruits are comparatively expensive sources of protein as compared with flour or dried legumes, the fruit juices being the most expensive and the dried fruits the cheapest of the fruit products. Ten cents on an average will purchase fully as much energy when spent for fresh fruits and more when spent for dried fruits than for lean meats, but much less than when expended for wheat flour. From the data as a whole it is apparent that fruits are reasonably cheap sources of energy in the diet and are well suited on grounds of economy for combination in reasonable quantity with cheap proteid foods to furnish a well-balanced ration.

COOKING AND ITS EFFECTS ON FRUIT: JELLY MAKING.

As is the case with all vegetable foods, the heat of cooking breaks down the carbohydrate walls of the cells which make up the fruit flesh, either because the moisture or other cell contents expands and ruptures the walls or because the cell wall is itself softened or dissolved. Texture, appearance, and flavor of fruit are materially modified by cooking, and if thorough it insures sterilization, as in the case of all other foods. The change in texture often has a practical advantage, since it implies the softening of the fruit flesh so that it is more palatable and may be more readily acted upon by the digestive juices. This is obviously of more importance with the fruits like the quince, which is so hard that it is unpalatable raw, than it is with soft fruits like strawberries. When fruits are cooked without the addition of water or other material, as is often the case in baking apples, there is a loss of weight, owing to the evaporation of water, and the juice as it runs out carries some carbohydrates and other soluble constituents with it, but under ordinary household conditions this does not imply waste, as the juice which cooks out from fruit is usually eaten as well as the pulp. Cooking in water extracts some of the nutritive material present. Thus, a German investigator found that after boiling, apples and pears contained 4 or 5 per cent and peaches about 7 per cent less carbohydrates than the uncooked fruit. In this case also such removal of nutritive material is of no practical importance.

The idea is quite generally held that cooking fruit changes its acid content, acid being sometimes increased and sometimes decreased by the cooking process. Kelhofer[a] showed that when gooseberries were cooked with sugar the acid content was not materially changed, these results being in accord with his conclusions reached in earlier studies with other fruits. The sweeter taste of the cooked product he believed to be simply due to the fact that sugar masks the flavor of the acid.

It is often noted that cooked fruits, such as plums, seem much sourer than the raw fruit, and it has been suggested that either the acid was increased or the sugar was decreased by the cooking process. This problem was studied by Sutherst,[b] and in his opinion the increased acid flavor is due to the fact that cooked fruit (gooseberries, currants, plums, etc.) usually contains the skin, which is commonly rejected if the fruit is eaten raw. The skin is more acid than the pulp, as was shown by analyses of gooseberries, in which the skin was found to contain 2.7 per cent acid and the pulp 1.8 per cent. To determine whether acid is formed when fruit is cooked, Sutherst boiled a mixture of nearly ripe gooseberries in water for about 30 minutes and then measured the amount of acid by trituration with sodium hydroxid solution. The boiled portion was found to contain less acid than the raw, probably because some of the acid was volatile and passed off with the steam.

---

[a] Landw. Jahrb. Schweiz., 19 (1905), pp. 601, 602.

[b] Chem. News, 92 (1905), No. 2393, p. 163.

As regards the effect of cooking on the kind and amount of sugar present, uncooked gooseberries were found to contain 1.2 per cent cane sugar and 5.8 per cent invert sugar. After boiling, no cane sugar was found while the invert sugar amounted to 6.9 per cent. This indicates that all the sugar undergoes inversion during cooking, the acid present bringing about the inversion in the usual way.

When fruits or fruit juices are cooked with sugar, the material very commonly solidifies or jellies on cooling, and this well-known property is taken advantage of in jelly making. In the case of some fruits, like the apple, the jelly-yielding material must be extracted from the fruit by cooking with hot water, while in the case of other fruits—the currant, for instance—this extraction with hot water is not necessary, as the expressed juice will produce a jelly. Heating the extracted or expressed juice is commonly considered a necessary step in jelly making, but some fruit juices will, on standing, jelly without heat, and laboratory tests have shown that jelly may also be obtained without the addition of sugar. Cooking and the addition of sugar are, however, important features in the practical consideration of jelly making, as they have a decided effect upon the yield, flavor, and keeping qualities of the resulting product.

Some fruits, like the ordinary varieties of pear, possess so little of the jelly-yielding material or possess it in such an unusual form that they do not yield a good jelly under ordinary household methods of treatment. The proportion of jelly-yielding material, like other constituents, varies with the stage of maturity, underripe rather than overripe fruit being best for the purpose.

The jelly-yielding bodies are known to be carbohydrates and have been called pectin, pectose, pectin bodies, or some similar name. They have been commonly grouped with the plant gums and similar carbohydrates, and the true nature of these materials has been the subject of a great deal of study.[a] At the present time the consensus of opinion seems to be that the pectins are composed of several of the simpler carbohydrates united to form a complex carbohydrate. In some fruits, like the apple, where the jelly-yielding material must be extracted with hot water, the pectin is apparently united with cellulose as a part of the solid pulp. As shown by the investigations of Bigelow and Gore at the Bureau of Chemistry, 40 per cent of the solid material of apple pulp may be thus extracted with hot water, and consists of two carbohydrates, one of which is closely related to gum arabic. That such carbohydrates as these should yield a jelly is not surprising when we remember that they are similar to starch in their chemical nature, and, as every one knows, starch, though insoluble in cold water, yields when cooked with hot water a large proportion of paste which jellies on cooling.

---

[a] The Bureau of Chemistry of the Department of Agriculture has reported a number of important studies on the jelly-yielding constituents of fruit and an extended summary of previous investigations of the chemical nature of pectins and related questions. U. S. Dept. Agr., Bureau of Chemistry Bul. 94; Jour. Amer. Chem. Soc., 28 (1906), p. 200.

When fruits are used for making pies, puddings, etc., the nutritive value of the dish is, of course, increased by the addition of flour, sugar, etc., and the dish as a whole may constitute a better balanced food than the fruit alone. It is commonly believed that dishes in which fruits are cooked with the addition of sugar, butter, and a flour crust of some sort are less easily digested than simple rations of bread, butter, and fruit having an equivalent nutritive value. The large number of digestion experiments which have been made with various mixed diets do not indicate that there is any special difference between the two rations as regards thoroughness of digestion, but additional experiments must be undertaken before it can be said with certainty whether or not there are actual differences in the ease and rapidity of digestion.

In different countries opinions vary markedly regarding the relative wholesomeness of raw and cooked fruit. Thus, as has often been pointed out, the Germans use comparatively little raw fruit and consider it far less wholesome than cooked fruit. On the other hand, in the United States raw fruit of good quality is considered extremely wholesome, and is used in very large quantities, being as much relished as cooked fruit, if indeed it is not preferred to it. It has been suggested that the European prejudice against raw fruit may be an unconscious protest against insanitary methods of marketing or handling and the recognition of cooking as a practical method of preventing the spread of disease by fruit accidentally soiled with fertilizers in the fields or with street dust.

OVERRIPE, DECAYED, AND UNRIPE FRUIT.

Overripe fruit is often injurious, very probably because it has begun to ferment, and stale or partially decayed fruit is obviously undesirable for food purposes. In addition to a deterioration in flavor there is always the possibility of digestive disturbance if such fruit is eaten raw. Of course, where apples are raised or where they are bought in large quantities for family use the thrifty housewife will sort them over and use for cooking the sound portions of those which have begun to decay. In such cases, however, the best available methods of storing should be followed and sorting should be done at frequent intervals, for if decay has proceeded very far the flavor is without doubt injured.

If fruits could be kept unbruised and with the skin unbroken, decay would be much delayed, as the mold spores, rots, etc., which cause decay, find their readiest entrance through broken skins. That mechanical injuries are the principal causes of decay was shown in a study of citrus fruits. When the skin of an orange or lemon is broken the blue mold finds access to the wound, and under favorable conditions of moisture and temperature develops readily and causes decay. An examination of hundreds of boxes of California oranges showed that a large percentage of all the fruit was made susceptible to such decay by accidental injuries to the skin in packing.

It is not at all strange that decayed fruit should have a decided characteristic odor and flavor when we remember that the decay is very commonly caused by fungi, especially molds and rots, which penetrate the pulp and grow and develop rapidly. The fungi live upon the cell contents, particularly sugars and proteids, and produce bodies of marked chemical characteristics, including odor and flavor. It is said that the most unpleasant effects are due to one of the common molds.

It is almost universally believed that green fruit is unwholesome and causes serious digestive disturbances, yet those who have been brought up in the country know that if illness had always followed eating it there would have been few well children in the community in the summer. Recognizing that green fruit may be a cause of illness at times and at other times apparently harmless, two German scientists have recently carried on extensive studies to ascertain the truth of the matter. Chemical analyses were made of fruits of varying degrees of ripeness, and studies in which green fruit was eaten in considerable quantities and under varying conditions were carried on with both animals and men. It appears from the results of the experiments that although unripe fruit is undoubtedly often harmful, particularly for children, the danger from such foods, especially green gooseberries, plums, pears, and apples, when eaten raw, is less than is commonly thought, and the effects depend in marked degree upon individual peculiarities.

The green fruit was found to contain the same chemical compounds as the ripe fruit, though in different proportions—that is, no chemical element was found in the green fruit which was foreign to the ripe fruit and which could be considered in itself a cause of illness. The injurious effects of raw unripe fruit therefore, it appears, do not depend upon chemical constituents, but rather on the unusual proportions in which the constituents occur, and especially the large percentage of hard cell tissue, which, if imperfectly masticated, it will readily be seen, might be a source of digestive derangement. Possibly the excess of acid in the green fruit is also a cause of digestive disturbance. Cooked green fruit was found to be practically harmless, being especially palatable and wholesome when cooked with sugar.

The possibility of injury by bacterial contamination was considered, though the data available were not sufficient for final deductions. It is now well known that such diseases are usually caused by micro-organisms, so possibly the green fruit very frequently picked up beneath the tree is only an accidental carrier of the real cause of the digestive disturbances which may follow eating it.

HANDLING AND MARKETING FRUIT.

It is very important that fruits should be handled, stored, and marketed under sanitary conditions, as they are very commonly eaten raw, and not all persons are careful to wash them before serving. Fruit which has fallen to the ground may be readily soiled with earth, water, or other material which may contain typhoid or other bacteria. Indeed, cases of infection have been traced to fruits contaminated in this or some similar way and which were eaten raw without being washed. Investigations have also shown that fruits exposed to street dust and to other unfavorable conditions become covered with bacteria, which are always present in such dust-laden air, and may be possible sources of contagion. Flies and other insects are also known to be a source of dirt and contamination. Samples of fruit purchased in the street and examined by a German investigator (Ehrlich) showed tuberculosis bacteria and many other forms of micro-organisms, the number present varying considerably with different sorts of fruit.

Realizing that fruit exposed to street dust and insects may be a means of spreading disease, measures have been taken in Vienna to prevent such conditions, and fruit offered for sale must be covered with gauze or otherwise protected. In connection with the Vienna investigations microscopic examinations were made of the skins of plums and pears purchased at a much patronized fruit shop. It was found that the main source of contamination was dust containing fragments of stone from the street pavement and bits of horse manure.

As might be expected, Ehrlich found that those fruits with a firm dry skin, such as apples, did not furnish as good a lodging place for bacteria and dust as fruits with a sticky surface, such as berries. Sticky dried fruits, such as dates, raisins, and figs, are also, as will be readily seen, favorable resting places for dirt and dust, as almost anything which the moving air currents lodge on the sticky surface will remain there. Fortunately, it is becoming a common practice to market such fruits in closed packages, usually of cardboard, which protect them to a great extent from dust and insects, so that the dried fruit, if clean in the first place, will remain clean.

It is often urged that washing fruit destroys flavor. On the other hand, skillful housewives maintain that if properly done the loss of flavor is inappreciable, and on the grounds of common cleanliness it would seem best to sacrifice a little flavor, if necessary, for the sake of removing filth and possibly dangerous bodies, even if the amount of dirt present is too small to be offensive to sight or taste.

Ehrlich, whose work has been cited, found that washing fresh fruit once thoroughly in running water was sufficient to remove the microorganisms present. If the fruit had been kept until the sticky surface was more or less dry, washing two or three times was found desirable. With apples and pears he recommends wiping with a clean dry cloth, followed by rinsing under the water tap. As is well known, berries, and other soft fruits sour and mold very readily if damp; they should therefore be washed just before they are served.

When fruit is washed the amount of material removed is small. In the case of soft fruits, like berries, with a surface skin which is very thin and easily broken, it is almost certain that larger quantities will be removed than with firm fruit.

An idea of the amount of material removed by washing fresh fruits, such as the apple, which is protected by a firm skin, may be gathered from some French experiments made to study the effects of washing apples used in cider making. Each apple in a 45-pound lot was washed separately in distilled water. The wash water took on a dirty black color and also had a disagreeable odor, and analyses showed that per 1,000 pounds of apples it contained about 0.3 pound total dry matter, the greater part of the dry matter being made up of sugar, with smaller amounts of pectin bodies, malic acid, and ash. The juice of washed and unwashed fruit was practically identical in composition. It is evident that the loss represented is too small to be of any practical account from the standpoint of economy, but even less than 0.3 pound of dirt per 1,000 pounds of fruit is something which all would wish to avoid when attention has once been directed to it.

On the whole, it seems fair to conclude that, notwithstanding the prejudice which many housewives have against the practice of washing fruit, it is unquestionably safest never to omit the precaution of washing fruit which is to be eaten raw, unless one can be quite certain that it has not been exposed to possible contamination.

Metchnikoff[a] insists that there is danger of acquiring harmful intestinal parasites or their eggs from raw fruits and vegetables, particularly those liable to come in contact with the soil, and he believes that in all such doubtful cases these foods should be cooked, or at least scalded in hot water, before they are eaten.

Much of the dust and dirt and other unpleasant features might be avoided if our methods of handling and marketing fruit and other food products were at all comparable with our standards of sanitation in other lines and with what is easily possible. Improvements in present market conditions, however, can hardly be expected until the public demands them.

STORING FRUIT.

The manner in which fruits are transported and stored has a marked effect on quality. Low temperature retards after-ripening and decay and is the agent most depended upon at the present time, and refrigerator cars and cold-storage warehouses are now very common adjuncts of the fruit industry. It is said that a temperature of 31 to 32° F. is best for storing apples, pears, peaches, and oranges. Another authority gives 32° F. for cantaloupes and watermelons, 33 to 34° F. for cranberries, 34 to 36° F. for berries and bananas, 36° F. for lemons, and 35 to 40° F. for dried fruits. Tender fruits, it is said, will keep best if they are stored just when they are fully ripe, and sweet fruits will stand a lower temperature than sour fruits. The length of time fruits may be kept in cold storage varies with the kind, the degree of ripeness, the method of handling, and other conditions. With berries, it is a question of days; with peaches, melons, and other soft fruits, of weeks; and with apples and pears, of months.

Though pears of suitable varieties are frequently kept for winter use, apples are the fruit most commonly stored in the household, at least in the central and northern regions of the United States. For success a uniform temperature is essential, the nearer 32° F. the better. The air of the cellar or the storeroom must be moderately dry; that is, it must be moist enough to prevent fruit from shriveling and dry enough to be unfavorable to mold growth. The room must also be sweet and clean, as fruits will readily absorb unpleasant odors. Apples kept too near the turnip bin are very apt to have an unpleasant taste. It is also best to avoid drafts, especially when storing pears. Barrels and bins each have their advocates, but the consensus of opinion seems to be that both are satisfactory and the choice of one or the other simply a matter of convenience. If it is desired to keep apples or pears an unusually long time, the individual fruits should be wrapped in clean unprinted paper which is not too thick. A great many of the problems connected with the handling and storing of fruits have been studied in the Pomological Investigations of the Bureau of Plant Industry of this Department and by several of the agricultural experiment stations.

---

[a] The New Hygiene. London, 1906, p. 36.

THE HYGIENE OF FRUIT.

Generally speaking, fruits are wholesome and palatable foods, yet it is not at all uncommon to find that one or more sorts can not be eaten by an individual. Thus many persons find that strawberries cause distress and many others that any acid fruit is a cause of digestive disturbance. Such cases are explained on the ground of some personal idiosyncrasy.

The extended use of fruit in the diet is certainly justified on the ground of palatability, food value, and esthetic considerations, but there are those who seek a further justification on the score of hygiene. It is commonly conceded that most fruits are laxative, and it seems probable that they owe this property to the considerable amount of water which they contain, to the salts in solution, or to the irritating crude fiber, small seeds, or other indigestible materials present, or to all these together. Man seems to crave and require some acid in his diet, and the citric, malic, and other fruit acids are undoubtedly wholesome.

The importance of fresh fruits and green vegetables in supplying the body with iron and other mineral matters is often spoken of, and it is true that the amount of iron, for instance, which many such foods contain is large in proportion to their protein content or their energy value. This means that if the ordinary diet does not supply enough of some mineral constituent it may be obtained by adding the fruit or green vegetable, which will give it without materially adding to the nutrients and energy of a diet already abundant in these respects.

Considerable bulk is an essential factor in the diet. If the foods eaten were of such a nature as to be almost completely absorbed, the large intestine would not readily empty itself and serious complications would follow. For this reason bulky foods, like fresh succulent vegetables and fruit, are of importance, as they usually contain a considerable proportion of indigestible matter.

In earlier times remarkable virtues or the opposite were commonly attributed to fruits, plants, precious stones, and other animate and inanimate objects, and it seems not improbable that the medicinal virtues which are often ascribed to various fruits in popular writings are survivals of this custom. No well-informed person would to-day share the belief, once so widespread, that tomatoes are the cause of cancer, yet many apparently give credence to statements that certain fruits are a satisfactory food for brain workers, while others must be avoided. At any rate, such statements are often found in print. In general, it may be said that very few investigations have been made which indicate that the different fruits possess specific medicinal qualities. Those which contain an abundance of sugar are naturally excluded in a large measure from the diet of diabetics, while there are other conditions in which acid fruits are conceded to be undesirable.

To the juice of acid fruits like the lime, lemon, orange, pomelo, or "grape fruit," and the kumquat (the small orange which is eaten entire, both skin and pulp) hygienic properties are commonly attributed, and there is reason to believe that this reputation is deserved. Such fruit juices stimulate the appetite and are beneficial in other ways. The bitter principle in the pomelo is commonly said to be of value medicinally, perhaps because it suggests the bitter flavor of quinine, but so far as can be learned the real value of this bitter quality is a matter of opinion rather than of experimental study.

Some fruits, notably the tropical papaw and the pineapple, contain very active ferments. The ferment present in the papaw is separated in commercial quantities and used as a digester of nitrogenous materials. Perhaps it is quite natural that much stress should have been laid on the ferment present in the pineapple and that this fruit should be recommended for use at the end of a meal, so that its ferment may aid the body in digesting food. It should be remembered, however, that the body in health does not need artificial aid in performing its normal functions and that for digestive disturbances it would be wiser to seek competent medical advice than to depend on the casual use of pineapple or other plant ferment, especially when it is remembered that there is great doubt as to the efficacy of any ferments introduced artificially into the stomach.

Fortunately there are so many other good reasons for using fruits that we have little need to base our use of them in quantity on supposed medicinal virtues.

EXTENT OF THE FRUIT INDUSTRY IN THE UNITED STATES.

As shown by statistics based on the results of dietary studies of nearly 400 American families, fresh fruits make up 3.8 per cent of the total food and supply 2.5 per cent of the total carbohydrates. Similarly dried fruits furnish 0.6 per cent of the total food and 1.2 per cent of the total carbohydrates. The values for fruits as a whole, therefore, are 4.4 per cent of the total food material and 3.7 per cent of the total carbohydrates. These figures are not large in themselves, yet compare favorably with the values for different groups of vegetable foods. Thus the same compilation shows that vegetables, other than legumes, potatoes, and sweet potatoes, furnish 6.2 per cent of the total food and 1.7 per cent of the total carbohydrates of the average American diet.

Besides the fruit consumed at home a great amount is exported, and there is no doubt that fruit growing is one of the important agricultural industries of the United States, and one which is rapidly developing. The report of the Twelfth Census[a] shows that the total value of fruit grown in contiguous United States in 1899 was in round numbers $131,099,000, of which orchard fruits made up $83,751,000, grapes, $14,090,000, small fruits $25,030,000, and oranges, lemons, and other subtropical fruits, $8,228,000. Of the individual States, California and New York were the greatest fruit producers, the large acreage of orchard fruits and grapes in these States being prominent factors in the problem.

The progress of fruit production during the decade between the last two censuses is indicated by the gain in the number of orchard fruit trees; the number of these trees in 1900 was 90 per cent more than the number in 1890.

Of orchard fruits the apple has decidedly the first place, 55 per cent of the total number of fruit trees in the United States in 1900 being apple trees, and this fruit making up 83 per cent of the total number of bushels of orchard fruit produced. Judged by the number of trees under cultivation the greatest increase has been found in the case of plums, apricots, and pears, though peaches and cherries also have shown large gains. Of small fruits strawberries, as might be expected, were the most important crop, and raspberries next, 257,438,000 quarts of strawberries and 76,628,000 quarts of raspberries having been grown in 1899.

In the case of canned and preserved fruits and similar goods the Census returns[b] give later figures than those quoted for fresh fruits. The total value of the canned fruit produced in 1904 was in round numbers $11,644,000, dried fruit, $15,665,000, and other fruit products $5,571,000, or a total of $32,880,000. Of the individual canned and preserved fruits the peach ranked first, the value of the peaches canned in 1904 being $3,894,000, with canned pears at a value of $2,192,000 ranking next.

Considering dried fruits, raisins ranked first, the total value of the raisin crop in 1904 being $6,349,000.

In 1906 the United States imported prepared, preserved, and dried fruits to the value of $5,337,000. The value of the domestic exports of dried, canned, and preserved fruits was $7,635,000.

---

[a] Bur. of the Census [U. S.] Rpts., vol. 6 (Agriculture, pt. 2), p. 599.

[b] Bur. of the Census [U. S.], Bul. 61, p. 9.

The statistics which have been quoted show a decided gain in the American fruit industry, both as regards fresh and preserved fruits, and there are reasons for believing that even the present development represents only a beginning. This being the case, it is easy to understand why the agricultural experiment stations have devoted so much of their time to the study of fruit products, the marketing of fruit, and related problems, and why the place of fruit and fruit products in the diet and their value as food should be regarded as an important subject for investigation.

CONCLUSIONS.

In general, it may be said that fruits are wholesome, palatable, and attractive additions to our diet, and may be readily made to furnish a considerable part of the nutrients and energy required in the daily fare. Fresh fruits are dilute foods and closely resemble green vegetables in total nutritive value, but dried fruits and many preserves, etc., are much more concentrated, comparing favorably with some of the cereals and other dry vegetable foods in the amount of total nutrients and energy which they supply per pound. The characteristic chemical constituents of fruits are carbohydrates, and so they are naturally and properly used in a well-balanced diet to supplement foods richer in protein, as cereal grains, legumes, nuts, eggs, dairy products, meats, and fish. Fruits contain considerable mineral matter, and as they are dilute foods they may be added to the diet to supply iron and other mineral constituents without unduly increasing the supply of protein and energy. Since they are bulky and often contain fairly large proportions of indigestible material, fruits stimulate what might otherwise be a sluggish intestine. Intelligently used, fruits are a valuable part of a well-balanced diet and may well be eaten in larger quantities than at present.

FARMERS' BULLETINS.

following is a list, by number, of the Farmers' Bulletins available for distri-
. The bulletins entitled "Experiment Station Work" give in brief the
s of experiments performed by the State experiment stations. Titles of other
ins are self-explanatory. Bulletins in this list will be sent free to any address
United States on application to a Senator, Representative, or Delegate in Con-
or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have
liscontinued, being superseded by later bulletins.

e Feeding of Farm Animals. Pp. 40.
g Cholera and Swine Plague. Pp. 16.
anuts: Culture and Uses. Pp. 24.
ax for Seed and Fiber. Pp. 16.
eeds: And How to Kill Them. Pp. 30.
uring and Other Changes in Milk. Pp. 22.
ape Diseases on the Pacific Coast. Pp. 15.
os and Silage. Pp. 30.
ach Growing for Market. Pp. 24.
ats: Composition and Cooking. Pp. 31.
tato Culture. Pp. 24.
tton Seed and Its Products. Pp. 16.
ion Culture. Pp. 30.
wls: Care and Feeding. Pp. 24.
cts About Milk. Pp. 32.
mmercial Fertilizers. Pp. 38.
igation in Humid Climates. Pp. 27.
sects Affecting the Cotton Plant. Pp. 32.
e Manuring of Cotton. Pp. 16.
eep Feeding. Pp. 24.
ndard Varieties of Chickens. Pp. 48.
e Sugar Beet. Pp. 48.
me Common Birds. Pp. 48.
e Dairy Herd. Pp. 30.
periment Station Work—I. Pp. 30.
e Soy Bean as a Forage Crop. Pp. 24.
e Keeping. Pp. 48.
ethods of Curing Tobacco. Pp. 24.
paragus Culture. Pp. 40.
rketing Farm Produce. Pp. 31.
re of Milk on the Farm. Pp. 40.
cks and Geese. Pp. 55.
periment Station Work—II. Pp. 32.
eadows and Pastures. Pp. 30.
e Black Rot of the Cabbage. Pp. 22.
periment Station Work—III. Pp. 32.
sect Enemies of the Grape. Pp. 23.
sentials in Beef Production. Pp. 24.
ttle Ranges of the Southwest. Pp. 32.
periment Station Work—IV. Pp. 32.
lk as Food. Pp. 39.
e Liming of Soils. Pp. 24.
periment Station Work—V. Pp. 32.
periment Station Work—VI. Pp. 27.
e Peach Twig-borer. Pp. 16.
rn Culture in the South. Pp. 24.
e Culture of Tobacco. Pp. 22.
bacco Soils. Pp. 23.
periment Station Work—VII. Pp. 32.
sh as Food. Pp. 32.
irty Poisonous Plants. Pp. 32.
periment Station Work—VIII. Pp. 32.
kali Lands. Pp. 23.
tato Diseases and Treatment. Pp. 15.
periment Station Work—IX. Pp. 30.
gar as Food. Pp. 31.
od Roads for Farmers. Pp. 46.
ising Sheep for Mutton. Pp. 48.
periment Station Work—X. Pp. 32.
ggestions to Southern Farmers. Pp. 48.
sect Enemies of Shade Trees. Pp. 30.
g Raising in the South. Pp. 40.
illets. Pp. 30.
uthern Forage Plants. Pp. 48.
periment Station Work—XI. Pp. 30.
tes on Frost. Pp. 24.
periment Station Work—XII. Pp. 32.
eeds of Dairy Cattle. Pp. 48.
periment Station Work—XIII. Pp. 32.
ltbushes. Pp. 20.
rmers' Reading Courses. Pp. 20.
ce Culture in the United States. Pp. 28.
rmer's Interest in Good Seed. Pp. 24.
ead and Bread Making. Pp. 40.
e Apple and How to Grow It. Pp. 32.
periment Station Work—XIV. Pp. 28.

115. Hop Culture in California. Pp. 28.
116. Irrigation in Fruit Growing. Pp. 48.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 30.
120. Insects Affecting Tobacco. Pp. 32.
121. Beans, Peas, and other Legumes as Food. Pp. 38.
122. Experiment Station Work—XVI. Pp. 32.
124. Experiment Station Work—XVII. Pp. 32.
125. Protection of Food Products from Injurious Temperatures. Pp. 24.
126. Practical Suggestions for Farm Buildings. Pp. 48.
127. Important Insecticides. Pp. 46.
128. Eggs and Their Uses as Food. Pp. 40.
129. Sweet Potatoes. Pp. 40.
131. Household Tests for Detection of Oleomargarine and Renovated Butter. Pp. 10.
132. Insect Enemies of Growing Wheat. Pp. 38.
133. Experiment Station Work—XVIII. Pp. 32.
134. Tree Planting in Rural School Grounds. Pp. 32.
135. Sorghum Sirup Manufacture. Pp. 40.
136. Earth Roads. Pp. 24.
137. The Angora Goat. Pp. 48.
138. Irrigation in Field and Garden. Pp. 40.
139. Emmer: A Grain for the Semiarid Regions. Pp. 16.
140. Pineapple Growing. Pp. 48.
141. Poultry Raising on the Farm. Pp. 16.
142. Principles of Nutrition and Nutritive Value of Food. Pp. 48.
143. Conformation of Beef and Dairy Cattle. Pp. 44.
144. Experiment Station Work—XIX. Pp. 32.
145. Carbon Bisulphid as an Insecticide. Pp. 28.
146. Insecticides and Fungicides. Pp. 16.
147. Winter Forage Crops for the South. Pp. 40.
148. Celery Culture. Pp. 32.
149. Experiment Station Work—XX. Pp. 32.
150. Clearing New Land. Pp. 24.
151. Dairying in the South. Pp. 48.
152. Scabies in Cattle. Pp. 32.
153. Orchard Enemies in the Pacific Northwest. Pp. 39.
154. The Home Fruit Garden: Preparation and Care. Pp. 16.
155. How Insects Affect Health in Rural Districts. Pp. 19.
156. The Home Vineyard. Pp. 22.
157. The Propagation of Plants. Pp. 24.
158. How to Build Small Irrigation Ditches. Pp. 28.
159. Scab in Sheep. Pp. 48.
161. Practical Suggestions for Fruit Growers. Pp. 30.
162. Experiment Station Work—XXI. Pp. 32.
164. Rape as a Forage Crop. Pp. 16.
165. Silkworm Culture. Pp. 32.
166. Cheese Making on the Farm. Pp. 16.
167. Cassava. Pp. 32.
168. Pearl Millet. Pp. 16.
169. Experiment Station Work—XXII. Pp. 32.
170. Principles of Horse Feeding. Pp. 44.
172. Scale Insects and Mites on Citrus Trees. Pp. 43.
173. Primer of Forestry. Pp. 48.
174. Broom Corn. Pp. 30.
175. Home Manufacture and Use of Unfermented Grape Juice. Pp. 16.
176. Cranberry Culture. Pp. 20.
177. Squab Raising. Pp. 32.
178. Insects Injurious in Cranberry Culture. Pp. 32.
179. Horseshoeing. Pp. 30.
181. Pruning. Pp. 39.

182. Poultry as Food. Pp. 40.
183. Meat on the Farm: Butchering, Curing, and Keeping. Pp. 37.
184. Marketing Live Stock. Pp. 40.
185. Beautifying the Home Grounds. Pp. 24.
186. Experiment Station Work—XXIII. Pp. 32.
187. Drainage of Farm Lands. Pp. 38.
188. Weeds Used in Medicine. Pp. 45.
190. Experiment Station Work—XXIV. Pp. 32.
192. Barnyard Manure. Pp. 32.
193. Experiment Station Work—XXV. Pp. 32.
194. Alfalfa Seed. Pp. 14.
195. Annual Flowering Plants. Pp. 48.
196. Usefulness of the American Toad. Pp. 16.
197. Importation of Game Birds and Eggs for Propagation. Pp. 30.
198. Strawberries. Pp. 24.
199. Corn Growing. Pp. 32.
200. Turkeys. Pp. 40.
201. Cream Separator on Western Farms. Pp. 23.
202. Experiment Station Work—XXVI. Pp. 32.
203. Canned Fruits, Preserves, and Jellies. Pp. 32.
204. The Cultivation of Mushrooms. Pp. 24.
205. Pig Management. Pp. 40.
206. Milk Fever and Its Treatment. Pp. 16.
208. Varieties of Fruits Recommended for Planting. Pp. 48.
209. Controlling the Boll Weevil in Cotton Seed and at Ginneries. Pp. 32.
210. Experiment Station Work—XXVII. Pp. 32.
211. The Use of Paris Green in Controlling the Cotton Boll Weevil. Pp. 23.
213. Raspberries. Pp. 38.
215. Alfalfa Growing. Pp. 40.
216. The Control of the Boll Weevil. Pp. 32.
217. Essential Steps in Securing an Early Crop of Cotton. Pp. 16.
218. The School Garden. Pp. 40.
219. Lessons from the Grain Rust Epidemic of 1904. Pp. 24.
220. Tomatoes. Pp. 32.
221. Fungous Diseases of the Cranberry. Pp. 16.
222. Experiment Station Work—XXVIII. Pp. 32.
223. Miscellaneous Cotton Insects in Texas. Pp. 24.
224. Canadian Field Peas. Pp. 16.
225. Experiment Station Work—XXIX. Pp. 32.
226. Relation of Coyotes to Stock Raising in the West. Pp. 24.
227. Experiment Station Work—XXX. Pp. 32.
228. Forest Planting and Farm Management. Pp. 22.
229. The Production of Good Seed Corn. Pp. 24.
231. Spraying for Cucumber and Melon Diseases. Pp. 24.
232. Okra: Its Culture and Uses. Pp. 16.
233. Experiment Station Work—XXXI. Pp. 32.
234. The Guinea Fowl. Pp. 24.
235. Preparation of Cement Concrete. Pp. 32.
236. Incubation and Incubators. Pp. 32.
237. Experiment Station Work—XXXII. Pp. 32.
238. Citrus Fruit Growing in the Gulf States. Pp. 48.
239. The Corrosion of Fence Wire. Pp. 32.
240. Inoculation of Legumes. Pp. 8.
241. Butter Making on the Farm. Pp. 32.
242. An Example of Model Farming. Pp. 16.
243. Fungicides and their Use in Preventing Diseases of Fruits. Pp. 32.
244. Experiment Station Work—XXXIII. Pp. 32.
245. Renovation of Worn-out Soils. Pp. 16.
246. Saccharine Sorghums for Forage. Pp. 37.
247. The Control of the Codling Moth and Apple Scab. Pp. 21.
248. The Lawn. Pp. 20.
249. Cereal Breakfast Foods. Pp. 36.
250. The Prevention of Wheat Smu Smut of Oats. Pp. 16.
251. Experiment Station Work—XX
252. Maple Sugar and Sirup. Pp. 36.
253. The Germination of Seed Corn.
254. Cucumbers. Pp. 30.
255. The Home Vegetable Garden.
256. Preparation of Vegetables for Pp. 48.
257. Soil Fertility. Pp. 39.
258. Texas or Tick Fever and Its Pp. 45.
259. Experiment Station Work—XX
260. Seed of Red Clover and Its Impur
261. The Cattle Tick. Pp. 22.
262. Experiment Station Work—XX
263. Practical Information for Begin gation. Pp. 40.
264. The Brown-tail Moth and How Pp. 22.
265. Game Laws for 1906. Pp. 54.
266. Management of Soils to Conser Pp. 30.
267. Experiment Station Work—XX 32.
268. Industrial Alcohol: Sources an ture. Pp. 45.
269. Industrial Alcohol: Uses and Sta 29.
270. Modern Conveniences for the Pp. 48.
271. Forage Crop Practices in Wes and Western Washington. Pp
272. A Successful Hog and Seed-Corn 16.
273. Experiment Station Work—XX 32.
274. Flax Culture. Pp. 36.
275. The Gipsy Moth and How to Pp. 22.
276. Experiment Station Work—XXX
277. The Use of Alcohol and Gasoli Engines. Pp. 40.
278. Leguminous Crops for Green Ma 27.
279. A Method of Eradicating Johnso 16.
280. A Profitable Tenant Dairy Farm.
281. Experiment Station Work—XL.
282. Celery. Pp. 36.
283. Spraying for Apple Diseases and Moth in the Ozarks. Pp. 42.
284. Insect and Fungous Enemies o East of the Rocky Mountains.
285. The Advantage of Planting He Seed. Pp. 16.
286. Comparative Value of Whole and Cotton-Seed Meal in Fer ton. Pp. 14.
287. Poultry Management. (In press
288. Nonsaccharine Sorghums. Pp.
289. Beans. Pp. 28.
290. The Cotton Bollworm. Pp. 32.
291. Evaporation of Apples. Pp. 38.
292. Cost of Filling Silos. Pp. 15.
293. Use of Fruit as Food. Pp. 38.
294. Farm Practice in the Columbi lands. (In press.)
295. Potatoes and Other Root Crops press.)
296. Experiment Station Work—XLI.
297. Method of Destroying Rats. (I

O

Issued June 14, 1907.

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN 294.

FARM PRACTICE IN THE COLUMBIA BASIN UPLANDS

BY

BYRON HUNTER,
*Assistant Agriculturist, Farm Management Investigations,
Bureau of Plant Industry.*

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., March 28, 1907.

Sir: I have the honor to transmit herewith a description of th system of farm management employed in the uplands of the Columbi Basin, prepared by Mr. Byron Hunter, Assistant Agriculturist in th Farm Management Investigations of this Bureau, and recommen that it be published as a Farmers' Bulletin.

This bulletin is to be issued jointly by the United States Department of Agriculture and the Oregon and Washington agricultura experiment stations.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.

Introduction 7

Description of the region 7

Soils 11

Agricultural history 11

Cropping systems 13

Soil tillage 13

  Summer fallowing 13

    Methods of summer fallowing 14

  Tillage for spring crops 21

Varieties of wheat grown 22

  Spring wheats 23

    Little Club 24

    Red Chaff 24

    Jenkins 24

    Early Wilbur 25

    Bluestem 25

  Winter wheats 25

    Red Russian 26

    Jones Fife 26

    Fortyfold 26

    Turkey Red 27

The permanency of the single-crop system of farming 27

Conclusions 29

ILLUSTRATIONS.

Page.

Fig. 1. Relief map of parts of Oregon and Washington, showing the Columbia Basin 8

2. Map showing the rainfall at points in and near the Columbia Basin 9

3. Diagrams showing the monthly distribution of rainfall at points in the Columbia Basin compared with points on the Great Plains 10

4. A slicker 15

5. A weeder used principally in the Walla Walla Valley 16

6. A right-lap cutaway harrow, used as a substitute for the plow 17

7. A weeder used in parts of eastern Oregon 18

8. A corrugated roller used to pack the lower part of the furrow slice 19

9. A subsurface packer 20

B. P. I.—280.

FARM PRACTICE IN THE COLUMBIA BASIN UPLANDS.

INTRODUCTION.

Men can usually be found in different localities, here and there, who stand out as the most successful farmers of their respective communities. Intelligently meeting the difficulties confronting them, these men work out the problems of tillage and crop production in a satisfactory manner. By studying and comparing the methods of a large number of such men a vast amount of valuable information can be acquired in a comparatively short time that would require years of patient, intelligent labor to glean from individual experience.

During the three years the writer has had charge of farm management investigations in the Pacific Northwest, considerable time has been spent in studying farm practice in the Columbia Basin. Representative localities have been visited, and, so far as possible, the methods of the most successful farmers have been studied. The principal objects in undertaking this study were (1) to ascertain what methods of tillage are in actual use by the farmers of the region, together with the relative merits of the different methods, and (2) to determine, if possible, the localities and conditions under which each of the leading varieties of wheat succeeds best. In making this detailed study the writer had the advantage of being quite familiar with conditions in the beginning, having lived in the region studied for more than twenty years.

The methods of farm practice discussed in the following pages will doubtless be applicable to other sections of the country of similar character. For this reason a description of the region studied is given.

DESCRIPTION OF THE REGION.

The area covered in this study includes a portion of each of three States—Idaho, Oregon, and Washington. It consists of the wheat-growing lands of the Columbia Basin. The area is almost entirely surrounded by mountains. The Cascade Mountains lie to the west; the Bitterroot and the Coeur d'Alene mountains to the east; the

Okanogan Highlands to the north, and the **Blue Mountains** to the southeast.

Practically the whole of the area is covered by an immense mass of basalt, the result of a series of lava overflows. Subsequent to the last great overflow a large lake covered a portion of the area in northern Oregon and central Washington. Into this lake streams carried sand and mud, and volcanoes threw into it great quantities of dust and ashes. Because the deposits of this lake were first studied along John Day River in Oregon it is known as Lake John Day. In some localities the deposits of this prehistoric lake were hundreds of feet

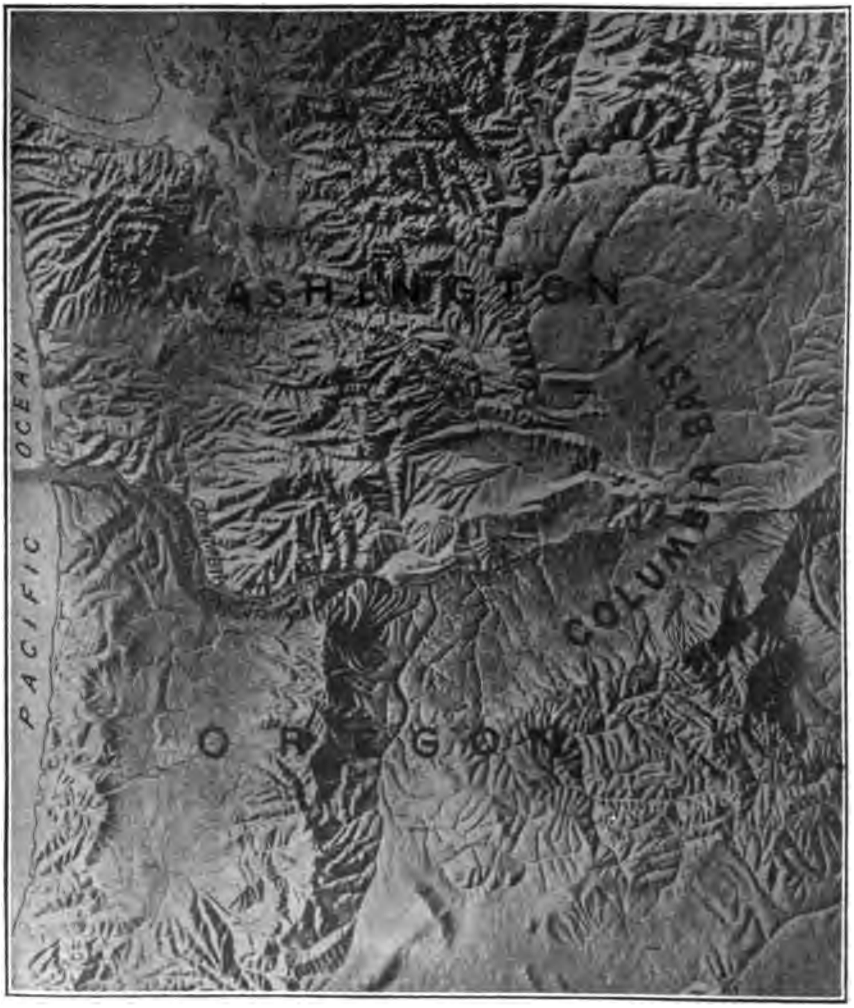


FIG. 1. Relief map of parts of Oregon and Washington, showing the Columbia Basin.

in thickness. Since the deposition of these sedimentary beds, the elevation and folding of the underlying Columbia basalt have given the country its present topography. Much of the sediment has also been removed by erosion, and streams have cut deep channels through the basalt, which, though very hard, rapidly disintegrates when exposed to air and water. The accompanying relief map (fig. 1) will give the reader a general idea of the topography of the country.

With the exception of the valleys along the streams, practically the entire area included in these studies consists of one vast expanse of undulating, treeless hills. In some localities the inclines are gentle, but the general surface is quite rolling. Near the mountains it is often steep. The elevation varies from a few hundred feet along the Columbia River to as much as 3,000 feet in parts of the eastern portion of the region.

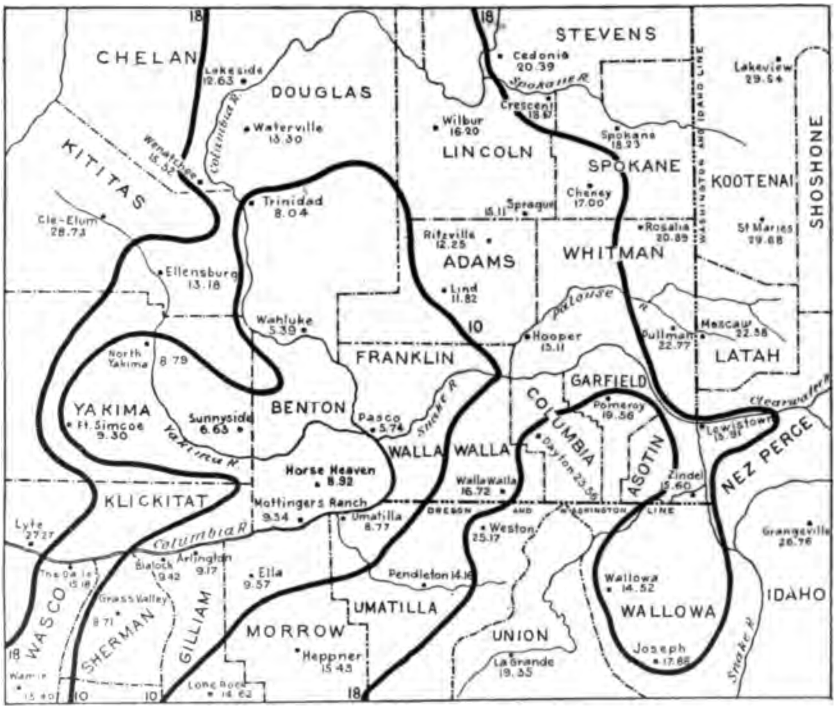


FIG. 2.—Map showing the rainfall at points in and near the Columbia Basin, expressed in inches.

The accompanying rainfall map (fig. 2), prepared from the reports of the United States Weather Bureau, shows the average annual rainfall to be less than 6 inches at points along the Columbia River. This gradually increases with the elevation and distance from the river until an annual rainfall of 23 or 24 inches is reached in the foothills of the Blue and the Bitterroot mountains.

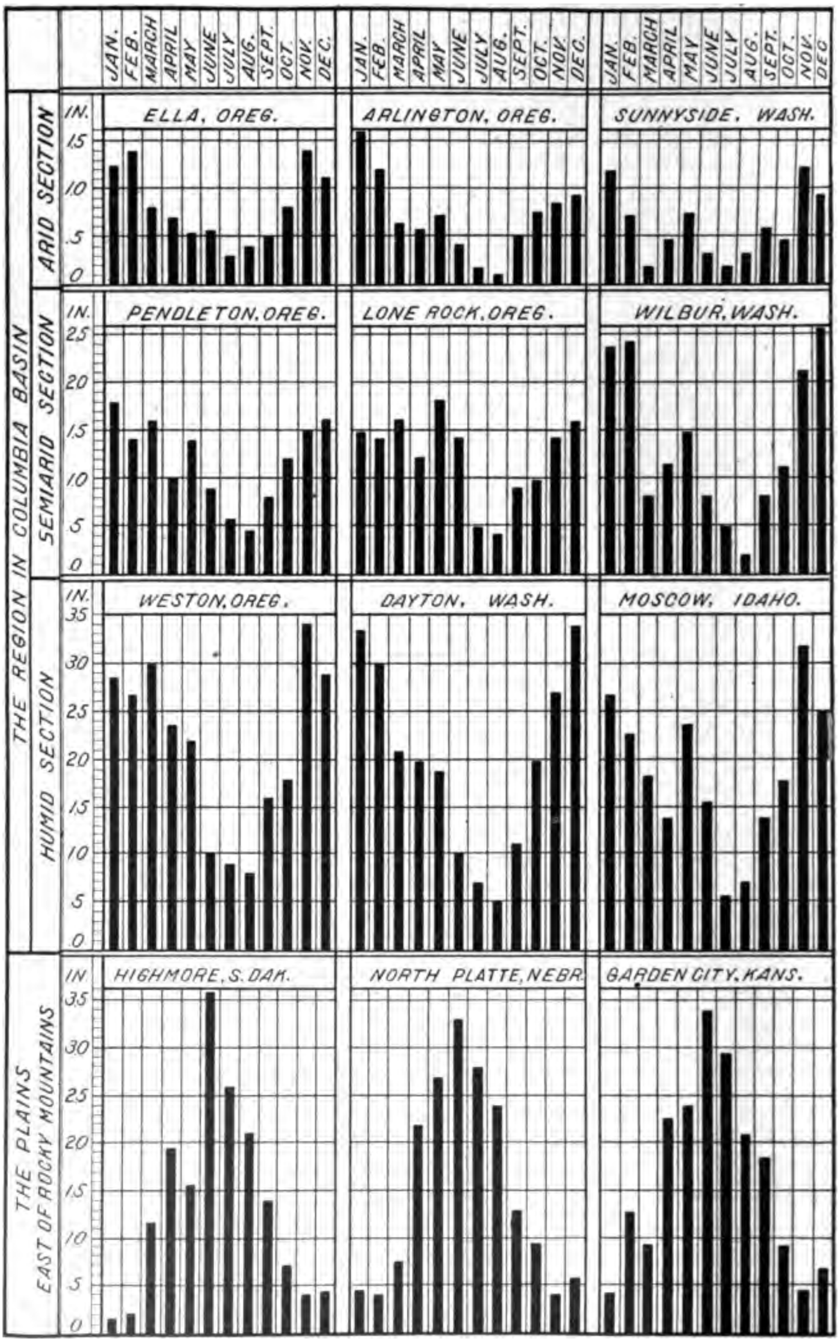


FIG. 3. Diagrams showing the monthly distribution of rainfall at points in the Columbia Basin compared with points on the Great Plains. The monthly rainfall in inches is shown by heavy vertical lines.

The average monthly rainfall of the arid, semiarid, and humid sections of the Columbia Basin is shown diagrammatically in figure 3. In order that the reader may realize the striking difference between the type of rainfall of the Columbia Basin and that of the Plains region east of the Rocky Mountains, figure 3 also includes the average monthly rainfall of Garden City, Kans., North Platte, Nebr., and Highmore, S. Dak.

Near the Columbia River, where the rainfall is lightest, it will be seen that the dry season extends from March to October, inclusive. Even during the winter months the rainfall is very scant. Eastward from the Columbia River the dry season gradually decreases in length and severity. Near the Blue and the Bitterroot mountains the dry season is confined entirely to the summer months, while the rainfall is quite well distributed throughout the remainder of the year. It must be remembered that in the Columbia Basin the rains are seldom torrential. Although the general surface is rolling the soil washes very little.

SOILS.

There are two general types of soils in the Columbia Basin—residual and sedimentary.

The residual soil occupies practically the entire wheat-producing area of the region. It is mainly the result of the weathering and disintegration of the Columbia basalt, and is a very fertile soil. In the eastern portion of the region—the humid section—it consists of of a friable, dark-brown silt loam, with a depth ranging from a few inches to about 3 feet. The subsoil consists of a light-brown silt loam. It is heavier and more compact and plastic than the surface soil, and affords good storage for moisture during the dry season. As the rainfall decreases this soil becomes lighter. In the drier localities it is a light-gray silt loam, with a depth of 6 or more feet. Owing to its light, ashy nature it is known locally as volcanic ash.

The sedimentary soil is the result of sediment and volcanic material deposited in ancient Lake John Day. It occupies an area of low altitude along the Columbia River and its tributaries. There is no definite line of demarcation between this and the residual soil. Most of this sedimentary type of soil that is under cultivation is irrigated. The residual soils are at higher levels, and are not irrigated.

AGRICULTURAL HISTORY.

There are two distinct agricultural sections in the Columbia Basin. One of these consists of the valleys along the streams, where irrigation is practiced; the other, of the upland prairies, where crops are produced without irrigation. It is only with the latter type of farming that this bulletin is concerned.

By referring to the foregoing rainfall map it will be seen that the central part of the Columbia Basin is exceedingly dry, while the eastern portion receives the heaviest annual rainfall. Because of these conditions settlements were first made in the eastern portion of the region, adjacent to the Blue and the Bitterroot mountains. When these first settlements were made it was thought that only a comparatively narrow belt of land adjacent to these mountains was of any value for farming. The remainder of the region was considered of value only for grazing purposes.

The first great impulse toward agricultural activity was felt from twenty-five to thirty-five years ago. Since the early settlement of these most humid sections the homesteader has gradually pushed agriculture back into the dry region, until now practically all of the land that will successfully produce crops without irrigation is under cultivation.

From the very beginning of the agricultural development of the region cereal crops have been grown almost exclusively. While alfalfa, timothy, corn, potatoes, fruit, etc., are produced in many parts of the country they all sink into insignificance when compared with the cereals, especially wheat.

The following table gives the acreage and production of the cereal crops in the Columbia Basin in 1899. Since that date large areas have been brought under cultivation and these figures would be materially increased in many of the drier counties were there complete data at the present time.

Acreage and production of barley, corn, oats, rye, and wheat in 1899, by counties.

NORTHERN IDAHO.

Counties.	Barley.		Corn.		Oats.		Rye.		Wheat.	
	Acres.	Bushels.	Acres.	Bushels.	Acres.	Bushels.	Acres.	Bushels	Acres.	Bushels.
Idaho	9,137	272,280	46	1,280	2,355	73,920	98	2,280	10,940	230,446
Latah	5,595	177,810	588	12,610	10,030	349,361	22	480	63,770	1,584,450
Nez Perce	12,565	380,600	1,167	28,210	4,673	166,500	14	360	53,178	1,110,280
EASTERN OREGON.										
Gilliam	3,394	43,870	25	420	448	6,420	513	4,900	45,950	406,480
Morrow	6,201	76,650	18	340	590	9,720	1,632	11,070	43,389	381,350
Sherman	1,763	42,230	158	2,650	1,718	34,120	56	680	91,100	1,050,400
Umatilla (and Reservation)	14,249	429,660	666	13,820	2,005	54,980	491	5,840	193,577	3,494,370
Wasco	3,544	75,700	1,310	14,150	2,424	49,280	83	750	39,510	504,980
EASTERN WASHINGTON.										
Adams	922	26,730	198	3,200	849	23,430	209	2,457	88,025	1,203,670
Asotin	3,853	70,260	43	1,910	30	320	74	1,020	9,406	103,950
Columbia	26,273	811,160	1,644	34,800	2,625	102,610	25	300	44,729	1,083,300
Douglas	4,403	77,490	447	9,230	3,278	66,590	145	1,030	64,286	757,123
Franklin			33	370					152	4,040
Garfield	23,067	655,990	142	3,810	43	1,990	240	4,800	40,588	799,890
Kittitas	2,888	88,150	19	410	2,041	76,150	67	2,528	8,574	199,310
Klickitat	3,207	78,340	237	2,410	2,468	57,890	315	4,220	49,328	766,360
Lincoln	9,560	239,020	239	4,640	3,409	96,780	207	3,816	218,942	3,618,930
Spokane	3,375	87,220	208	4,100	16,759	455,218	119	1,380	89,768	1,580,880
Wallawalla	11,484	382,190	1,209	32,140	1,913	77,556	515	5,590	152,993	3,853,910
Whitman	28,537	992,660	1,950	37,269	26,352	1,023,890	125	2,220	280,194	6,415,220
Yakima and Benton	1,914	36,920	697	17,550	1,004	33,090	401	3,560	16,394	210,240

In the eastern portion of the region—that which was brought under cultivation first—a cereal crop was produced annually for several years. Little attention was given to the quality of the seed sown and the land soon became infested with weeds, especially with wild oats. The yield also decreased and it became necessary to summer fallow occasionally.

CROPPING SYSTEMS.

A very large portion of the territory under consideration now produces a crop of wheat every other year, the wheat alternating with summer fallow. This system is uniformly followed in all localities where the rainfall is scant.

Near the mountains, where the rainfall is heavier, two crops are usually grown each time the land is summer fallowed. After summer fallowing a crop of winter wheat is usually grown; the crop that follows this may be either barley, oats, or wheat. In some instances two spring crops follow the winter wheat—first a crop of barley and then a crop of spring wheat.

SOIL TILLAGE.

Soil tillage in the Columbia Basin divides itself into two phases—summer fallow tillage and tillage for spring crops. The former will be considered first.

SUMMER FALLOWING.

When questioned as to why they summer fallow, farmers usually give three reasons:

(1) To conserve moisture. Considerable wheat is now produced on each side of the Columbia River with as little as 8 or 9 inches of rainfall. Under such dry conditions the land is summer fallowed every other year in order to conserve the rainfall of one year for the use of the growing crop the next season. Even near the mountains, where the rainfall is heaviest, the conservation of moisture is usually given as the important reason for summer fallowing.

(2) To eradicate weeds. When farm land becomes foul with weeds the yield of cereal crops is greatly diminished. The weeds rob the growing crops of both moisture and plant food.

(3) The third reason for summer fallowing given by farmers is variable. It is usually about as follows: To get the soil into such condition that it will produce satisfactory crops.

It is well understood that while land is being fallowed certain changes take place within the soil that give it renewed fertility. As to just what these changes are and how they take place, there is yet much to learn. However, some of the conditions that are favorable to these changes are known, and one of them is the maintenance of a moist, mellow, and thoroughly aerated surface soil. This condition, which is secured by plowing and frequent surface cultivation, is favorable to desirable bacterial life, the decomposition of the stubble and other organic matter that is incorporated into the soil by cultivation, and the production of available plant food.

Methods of Summer Fallowing.

In making the study previously referred to the following methods of summer fallowing were found in use in various parts of the country:

(1) **Late plowing with no cultivation.**—This method is practiced most frequently where there is considerable rainfall. The land is plowed just as late in the spring as possible, and no further cultivation is given. The object in plowing so late is to get all the pasture possible before plowing and to have the soil break up in a cloddy condition and become so dry before it is plowed that no weed seeds will germinate. If no weeds come many think that plowing is all the cultivation that is necessary. Cattle and horses, and in some instances sheep, are pastured on the summer fallow to keep the weeds down. Many do this class of work because they are farming two or three times as much land as can properly be handled with their equipment. Others profess to believe in it. If the rainfall is considerable and is well distributed through the growing season, good crops are often secured by this method. The advocates of this system say it is desirable to have the ground pass through the winter rough and cloddy in order that the depressions may catch the snow and rain water and prevent it from running off the surface. They further say that the soil runs together and becomes closely packed during the winter if it is finely pulverized, and that the lumpy condition secured by late plowing with no subsequent cultivation largely prevents this.

There are some serious objections to this system of summer fallowing. In the first place, it is not conducive to the conservation of [illegible] bacterial life, and to the decomposition of the [illegible] being freed from noxious [illegible] average yield of [illegible] summer fallowed [illegible] the acre than [illegible] the yield of [illegible] and summer [illegible]

[illegible] very common [illegible] quite generally [illegible] done in the spring as early as the ground is in good working condition. In practice the plowing is done as soon as the spring seeding is finished. Some follow the plow closely with the common tooth harrow. This settles the soil, pulverizes and dries the surface, and prevents the evaporation of a great deal of moisture. Others plow large areas before harrowing, permitting the soil to lie loose and open just as the plow leaves it. In this loose, open condition the air circulates through the soil too freely and dries it out very rapidly. Although it is not always done, it is usually the aim to do enough cultivating after plowing to control the weeds. Weeds are easiest destroyed just before or just at the time when they are coming through the surface of the ground. At this stage few implements are the equal of the common tooth harrow. After the weeds get too large for the harrow many farmers use the slicker (fig. 4), some form of a blade or knife weeder (figs. 5 and 7), or the disk harrow.

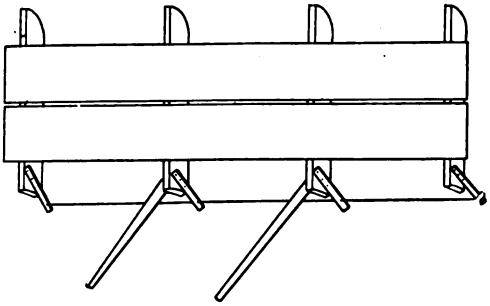


FIG. 4. A slicker.

The slicker is used in many parts of the country. It is easily and cheaply constructed. It is usually about 12 feet wide, with four runners. The runners are made of 2 by 6 inch or 2 by 8 inch scantling. Boards are nailed on top of the runners. An iron rod five-eighths of an inch in diameter is fastened at the back end of the runners so that it drags in the soil 1 to 2 inches below the surface. A thin bar of steel as long as the width of the implement, about 2 inches wide and sharpened on the front edge, is sometimes used instead of the iron rod. The bar is bolted to the bottom of the back end of the runners. The weight of the driver who rides the implement causes the rod or knife to run just under the surface of the ground. When the rod clogs, it is dumped by lifting on the handles shown in the cut. It works very nicely when the soil is smooth, finely pulverized, and reasonably free from stubble and other trash. When the slicker is to be used, care should be exercised in turning the stubble under well. The same care is necessary in the use of the blade weeders. Keeping the blades or knives sharp is one of the chief secrets in the successful use of these weeders. Most farmers cultivate only to destroy the weeds. Some realize the importance of saving the soil moisture and aim to cultivate several times, especially after rains, for this purpose.

Several instances came under the observation of the writer during the autumn of 1906 where sufficient moisture had been retained by this method of summer fallowing to germinate early-sown wheat and give good stands. There is no difficulty in doing this where the rainfall is heaviest, but the instances referred to were in localities having as little as 12 to 13 inches of rainfall.

(3) **Right lapping.**—Still another method of summer fallowing is that of right lapping. In parts of Adams and Franklin counties, Washington, the right-lap cutaway harrow (fig. 6) has been used for nine or ten years in cultivating summer fallow land. Where used this implement takes the place of the plow entirely.

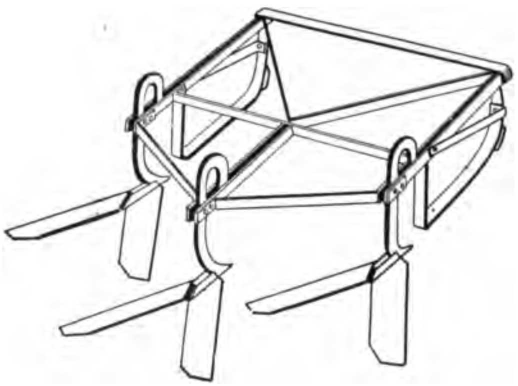


FIG. 5.—A weeder used principally in the Walla Walla Valley. By putting sections together it may be made as wide as desirable.

As soon as the spring seeding is done the land to be summer fallowed is cultivated with the right-lap. If there is no seeding to be done, this first cultivation is given just as early as the condition of the soil will permit. During the first cultivation the disks of the right-lap run about 4 inches deep. It will be seen that weed seeds are not covered too deeply to germinate. By the time the first cultivation has been completed—from four to six weeks—a crop of weeds has usually made its appearance on the ground first gone over, and it is necessary to begin the second cultivation immediately. The disks being large and set at a considerable angle will run from 5 to 6 inches deep and turn the soil and cover weeds quite well. This second cultivation usually destroys a good crop of weeds.

Usually two cultivations with the right-lap is all the cultivation given. [illegible] come again, some use the right-lap the [illegible] slicker, or some other form of [illegible] th this method, and it is [illegible] R[illegible]zville, Wash.

[illegible] harrow imme- [illegible] that a great [illegible] harrow would [illegible] right-lap cut- [illegible] too freely in

[illegible] awalla, Lin- [illegible] Perce County, [illegible] oming into use. It must be remembered that farmers are taking up this method independently of each other, and in localities that are separated by considerable distances. Just as early in the spring as the ground is in good working condition or as soon as the spring seeding has been completed, the land to be summer fallowed is disked. Some disk but once, while others double-disk and then use a smoothing harrow. Most farmers are ready to concede that the more cultivation given the better. By this surface cultivation a loose mulch is formed over the entire area to be summer fallowed much more quickly than it could be plowed. This saves much of the soil moisture, for evaporation always takes place rapidly in the spring from land that is packed by the winter rains. By the conservation of moisture in this way, plowing may be delayed as much as four or five weeks.

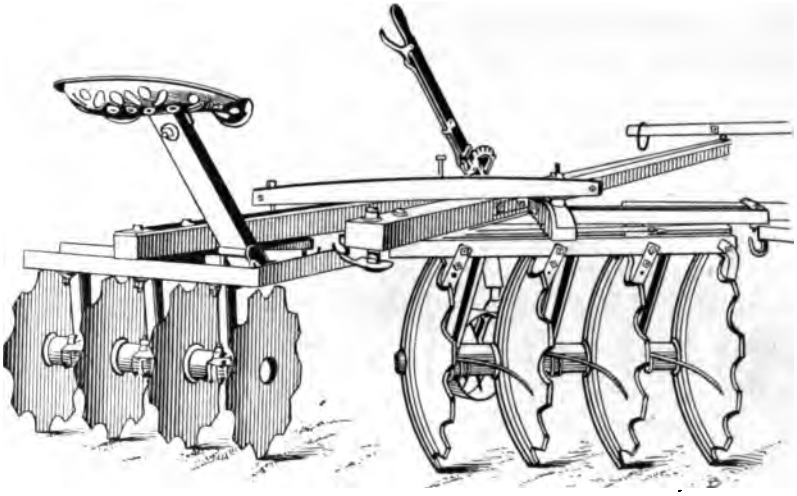


FIG. 6. A right-lap cutaway harrow, used as a substitute for the plow.

In parts of Lincoln County, Wash., where early surface cultivation is practiced the plowing is usually done just as late as possible. No other cultivation is then given. The summer fallow often lies over until spring before it is sown to wheat, and it is thought best to have it pass through the winter in a rough and cloddy condition. The reason for this is the same as that given in discussing the first method of summer fallowing, viz, to keep the soil from running together so much during the winter.

In most other localities where disking in the early spring is practiced, the plowing is done from four to six weeks after the land has been disked and harrowed. The land is plowed in the order in which it is disked, and the harrow closely follows the plow. It is usually the aim to do enough subsequent cultivation to keep the weeds subdued. Some realize the importance of cultivation to retain moisture, even though the land may be reasonably free from weeds. The writer knows of summer fallow land that received six and eight cultivations.

There is much to commend this method. The disking and harrowing in the early spring before plowing form a loose mulch on the entire area to be summer fallowed much more quickly than it could be plowed. This saves a great deal of moisture, for the land plowed last often becomes very dry when plowing is the first operation.

Most weed seeds germinate best if not covered very deeply. When lying on the surface of the ground, the plow often covers them so deeply that they do not germinate until turned up near the surface again by subsequent plowing. Early surface cultivation covers these seeds lightly and gives them a chance to germinate before the plowing is done. The plow then destroys a crop of weeds, usually a heavy one. In this way practically all of the weed seed of the previous season's crop may be germinated before plowing and a clean surface soil turned under.

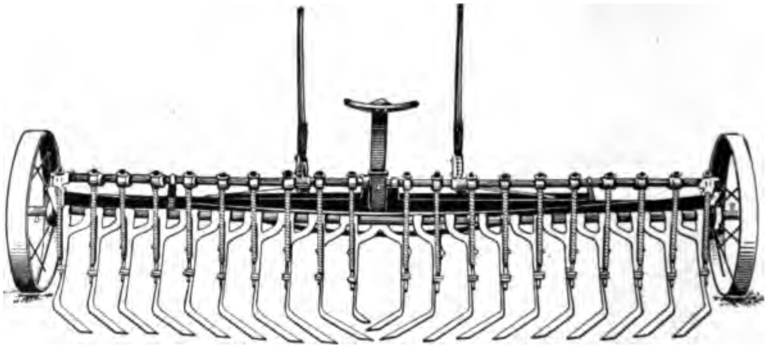


FIG. 7.—A weeder used in parts of eastern Oregon—an effective but expensive implement.

Early surface cultivation also causes the soil to plow more easily, and
makes [illegible] This is especially notice-
[illegible] fields in the fall in haul-
[illegible] habit of harrowing
[illegible] accidentally
[illegible] great deal of
[illegible] avy stubble.
[illegible] covers it,
[illegible] der much
[illegible] owing is not
[illegible] e immediate
[illegible] his condition

of the soil is favorable to the conservation of moisture and the germination of the weed seed turned up by the plow. Later cultivation destroys this crop of weeds and helps to retain moisture. The more moisture retained in the soil while fallowing the greater will be the decomposition of the stubble and other organic matter. Chemical action in the soil is also favored, thus providing more mineral plant food.

It will be seen that practically all of the soil turned by the plow can be cleaned reasonably well from weed seed. The thorough cultivation before plowing cleans the surface soil before it is turned under, and the subsequent cultivation cleans that which is turned up to the surface. In this way a clean seed bed is obtained. Men who are using this system say that land badly infested with wild oats can be cleaned reasonably well in this way by two years' summer fallowing, raising one crop of wheat in the meantime.

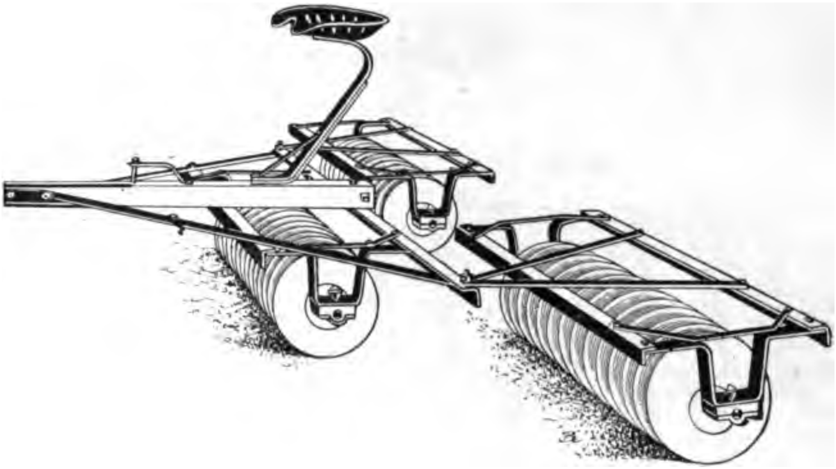


FIG. 8.—A corrugated roller used to pack the lower part of the furrow slice.

A few farmers make a practice of disking land in the early autumn that is to be fallowed the next summer. Were this to become a common practice it would be a valuable addition to the present methods. By early fall disking weed seeds are covered and caused to germinate, the soil is put in better condition to take the winter rain and snow, and stubble is covered, or partially so, and its decomposition hastened. The soil usually works much better in the spring, and less surface cultivation is needed before plowing.

(5) **Subsurface packing.**—In addition to the last method of summer fallowing described, two special implements are used in different parts of the country for settling and packing the lower portion of the furrow slice. One of these implements is a corrugated roller, the

corrugations of which are sharp and wedge shaped (fig. 8). The bevel of the corrugations reaches from the outer rim to the large axle to which the corrugations are attached. This roller has been used in the vicinity of Wasco, Oreg., for a number of years. The other implement, the subsurface packer, has been introduced more recently. It consists of a series of wheels upon a long shaft (fig. 9). The rims of these wheels are wedge shaped.

As explained before, land that has just been plowed is loose and open, containing many air spaces. This open condition permits the air to circulate quite freely in the soil, which dries it out quickly. While it is desirable that the air should enter the soil and that noxious gases arising from the decomposition of organic matter should escape, there is little danger of getting the lower portion of the soil turned by the plow into a too compact condition in at least the major portion of the Columbia Basin. In fact, summer fallow land usually dries out as deep as it is plowed because it is too open. In summer fallowing an effort should be made to get the bulk of the soil that has been turned by the plow, especially the lower portion, pulverized and packed so closely that the air will circulate in it very slowly.

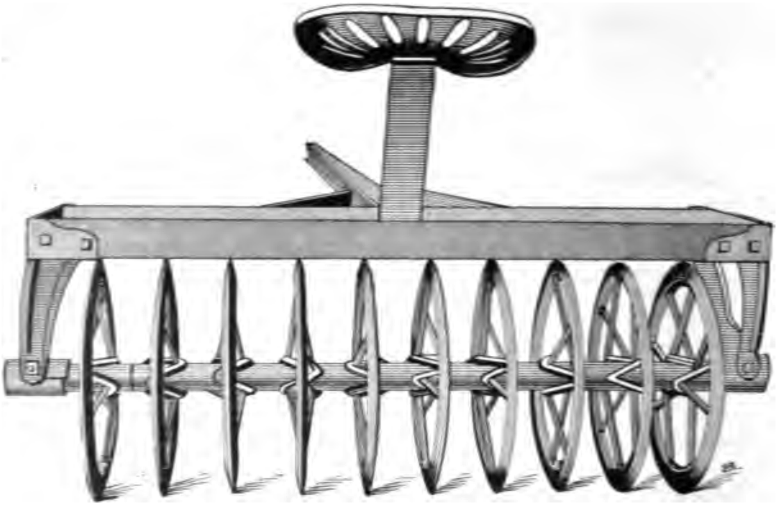


FIG. 9.—A subsurface packer.

When the corrugated roller or the packer is used on the summer fallow land it closely follows the plow. It should never be used when the soil is wet, for the packing will cause the soil to run together. But if the plowing has been done when the soil breaks up in a mealy, granular condition, the mashing of these wedge-shaped surfaces into the soil fills up the air cavities and presses the soil granules together without uniting them. This causes the air to circulate in the soil very slowly, and in this way the amount of moisture lost by evaporation is greatly reduced. Water passes from a soil that is moist and in this mealy, granular condition into a dry soil very slowly. In order to save the greatest amount of moisture, then, it should be the aim to dry the surface soil just as quickly as possible after plowing and packing. This is done by stirring the surface, usually with a common tooth harrow. The surface is then kept dry by frequent surface cultivations. In conserving moisture it is also very essential that the surface be stirred after each rain that wets down to the moist soil or forms a crust on the surface.

The following instance illustrates the value of subsurface packing in the Columbia Basin:

Mr. D. Buchanan summer fallowed 400 acres near Ritzville, Wash. With the exception of running the packer over 70 acres, the entire field received the same treatment. The whole field was sown to winter wheat. At harvest time the 70 acres outyielded the remainder of the field 5 bushels per acre. The corrugated roller has given about the same results in eastern Oregon.

TILLAGE FOR SPRING CROPS.

Tillage for spring crops is quite uniform throughout the Columbia Basin. The plowing is usually done in the spring as early as conditions of the soil and weather will permit. Too often the plow runs the same depth year after year, both when plowing summer fallow land and for spring crops. This causes a hard crust or false hardpan to form just under the plow furrow. Careful farmers prevent this crust from forming by varying the depth of plowing from year to year.

In addition to the plowing, the tillage given for spring crops usually consists of sowing the seed with a disk drill and harrowing the land twice. With no more cultivation after plowing than this, it is safe to say that the lower two-thirds of the soil turned by the plow is never pulverized or sufficiently compact. It is too loose and open; the air circulates through it rapidly and it dries out quickly.

The following illustrates the value of thoroughly settling and packing the soil when preparing it for spring crops:

Two farmers living in Lincoln County, Wash., had adjoining fields, with a road running between them. They plowed at the same time and at the same depth. They also sowed the same variety of wheat on the same day. One of them harrowed ten times as much as the other and harvested 27 bushels per acre to his neighbor's 17.

Where the corrugated roller and subsurface packer have been introduced, they are used for settling and packing the soil for spring crops. Farmers in eastern Oregon who use the corrugated roller say that their seed germinates much better and that the yield is several bushels more per acre when they use the roller just after drilling in the grain. They also say that it would pay to use this implement even though there were no increase in the yield. This is because the ground is so much firmer at harvest time, which enables them to cut the grain so much more easily and cheaply.

If neither the corrugated roller nor the subsurface packer is available the disk harrow is sometimes used instead. It is set perfectly straight and weighted to make it cut deeply. Used in this way it does very effective work in settling and packing the bottom of the furrow slice.

There is considerable fall plowing done for spring crops. It is generally conceded that better yields are secured from fall plowing than from spring plowing, provided the land is reasonably clean. There are several reasons for this. Soil left rough and porous as it comes from the plow holds the snow better and takes the snow and rain much better than land that is unplowed. By seeding time in the spring the winter rains have settled the soil sufficiently to form a good, firm seed bed. In other words, the winter rains put the bottom of the furrow slice in practically the same condition as does the subsurface packer or the corrugated roller. When in this condition there is a very much better upward capillary movement of the moisture than is usually secured from spring plowing. Again, by plowing in the autumn the stubble and other trash on the surface of the ground are covered and given a better chance to decay. Getting the stubble well covered is an important item, and to accomplish this the jointer or a chain is often attached to the plow beam. When the land to be summer fallowed is reasonably clean, some plow in the fall for these same reasons.

VARIETIES OF WHEAT GROWN.

There are many varieties of wheat grown in the Columbia Basin. The following list includes practically all of them: Little Club, Salt Lake Club, [illegible] Club, Crooked-Neck Club, Australian Club, Red Chaff, [illegible] Bluestem, Red Allen, White Elliott, [illegible] Klondike, Gold Coin, White Tuscan, [illegible] King, Wolf Hybrid, Canadian [illegible] Russian, Jones Fife, Arca- [illegible] durum wheat. [illegible] in any par- [illegible] the Colum- [illegible] held, in their [illegible] conditions. So [illegible] grown upon [illegible] concerned. [illegible] best varieties the conditions would be much more satisfactory. The varieties would then become standardized. The miller would know what he was buying, and the producer what he was selling.

To test and study all of these varieties of wheats sufficiently to determine which are best adapted to the arid, semiarid, and humid sections of the Columbia Basin is no small undertaking. So many of them have been grown for so short a time and in such small quantities that it is out of the question to pass reliable judgment upon them. Therefore, in the pages that follow only those varieties will be discussed that have been grown long enough and in sufficient quantities to warrant an estimation of their worth.

In selecting the most profitable wheat to grow, it is not always possible to satisfy both the farmer and the miller. A wheat of poor milling qualities may be a heavy yielder, and for that reason very profitable to the producer. What is said regarding the milling qualities of the wheats under consideration is based largely upon the answers to a circular letter sent to the millers of the Pacific Northwest. In judging the milling qualities of any variety of wheat the locality in which it is grown must be considered. Two samples of any variety of wheat, one grown under arid and the other under humid conditions, will differ very materially in milling qualities.

SPRING WHEATS.

Spring wheats are raised throughout the Columbia Basin. In the most humid part of the region, the eastern portion, spring varieties of wheat are sown in both autumn and spring. When sown in the fall on summer fallow land they are frequently winterkilled.

In that portion of the region with less than approximately 18 inches of rainfall (see rainfall map, p. 9), the prevailing methods of summer fallowing do not retain sufficient soil moisture to germinate early-sown wheat before the fall rains come. By referring to the table showing the monthly rainfall distribution (p. 10) it will also be seen that in the arid localities the fall rains do not come until November, while in the humid section they begin in the early autumn. In the semiarid section, between the arid and humid, the fall rains are uncertain.

In the arid section considerable wheat is sown during the fall in the dry soil. The grain then lies in the soil until the late rains come, when sufficient moisture can usually be relied upon to germinate the seed and sustain the young plants. Mr. W. W. Weatherford, of Gilliam County, Oreg., has farmed with approximately 10 inches of rainfall for twenty-five years. He always sows his wheat in the fall in the dry soil. Three times during the twenty-five years he has had to reseed. This was not because his grain germinated and then died from lack of moisture, but because it was winterkilled.

In the eastern portion of the region, under humid conditions, little difficulty is experienced in getting good stands of fall-sown wheat.

In the semiarid section, where the fall rains are uncertain, there is much greater risk in sowing wheat in the early autumn under the present methods of summer fallowing. It sometimes happens that just enough rain falls to germinate the seed, after which dry weather prevails. The young plants then die from lack of sufficient moisture for growth. Because of these difficulties in raising winter wheat much of the summer fallow land in the semiarid belt is not sown in the fall. It lies over until spring, when it is sown to spring wheat.

The following are some of the most important varieties of spring wheat now being grown.

Little Club.

The Little Club was probably one of the first varieties of wheat brought into the Columbia Basin. From its introduction until the present time it and Red Chaff have been the leading wheats grown along the foothills of the Blue Mountains. For years it was the leading wheat of the Palouse country. Until the last few years it was practically the only wheat grown in much of eastern Oregon. Although it is often sown in the fall it will not stand the winters nearly so well as some of the true winter varieties.

The Little Club wheat has a stiff straw, and unless the growth is very rank it will stand a long time after it is ripe without falling. It does not shatter easily. It is, therefore, admirably adapted to harvesting with the "combine"[a] and header. The Little Club variety yields well, and in its territory, the moist eastern portion of the Columbia Basin, few wheats are its equal. It is a standard wheat on the market.

Red Chaff.

The Red Chaff and the Little Club are very similar wheats. They are adapted to practically the same conditions and territory. In some localities the farmers prefer Red Chaff, while in others Little Club is the favorite. There seems to be little difference in their milling quali- [illegible] millers place Red Chaff first, while Little Club is [illegible]

[illegible]

[illegible] has red chaff, [illegible] that of the Little [illegible] ury conditions [illegible] years. Under these dry conditions it is said that the Jenkins variety yields a little more and stands the winters and hot weather a little better than the Little Club wheat.

---

[a] [illegible] the Pacific coast.

Early Wilbur.

The Early Wilbur also belongs to the Club type of wheats. It is about ten or twelve days earlier than the Jenkins and the Little Club varieties. Because of its earliness it usually fills and tests well when later wheats are shriveled by the dry, hot weather. Those growing this wheat speak of it very highly as a spring wheat. When sown in the fall it is easily winterkilled. When grown with about 10 inches of rainfall it is said to outyield the Jenkins and the Little Club varieties one year with another. When the rains continue late in the spring the Jenkins wheat yields the best. For the very dry localities the Early Wilbur variety should prove a very valuable wheat.

Bluestem.

Where the annual rainfall is less than 18 or 19 inches the Bluestem is usually the leading variety of spring wheat. There are possibly two exceptions to this, namely, in the vicinity of Waterville, Douglas County, Wash., where Red Allen is in the lead, and in parts of eastern Oregon where the Club varieties—Little Club, Crooked-Neck Club, Jenkins, and Early Wilbur—predominate. Where the annual rainfall is more than 20 inches it usually grows too rank and tall, and falls down.

The Bluestem variety is sown in both autumn and spring. It stands the winters poorly, however, when compared with the true winter varieties. It has a straw of good length, does not shatter easily, stands the dry hot weather well, and always commands a premium of from 2 to 3 cents over the Club varieties. The Bluestem contains a high percentage of gluten, and when milled produces a strong flour of superior white color. It is therefore a deservedly popular wheat with the millers.

WINTER WHEATS.

The winter varieties of wheat are grown throughout the Columbia Basin. In the arid and semiarid sections, where difficulty is experienced in getting satisfactory stands of fall-sown wheat on account of the lack of moisture, the spring varieties predominate. When a good stand of winter wheat is secured it is generally conceded that it will outyield spring wheat several bushels to the acre. Where the rainfall is sufficient to germinate early fall-sown grain, summer fallow land is always sown in the autumn.

The following are the principal varieties of winter wheat now being grown.

Red Russian.

For several years the Red Russian variety has been the leading winter wheat in eastern Spokane and eastern Whitman counties, Washington, and in Latah County, Idaho. It stands the winters very well, does not shatter easily, and yields satisfactorily. Because of the heavy growth of stems the Red Russian variety is one of the best wheats that has been found to crowd out wild oats. The milling qualities of this wheat are very poor, and it usually sells for 3 cents less than the Club variety and for 5 cents less than the Bluestem wheat. For these reasons its acreage is decreasing.

Jones Fife.

At the present time Jones Fife wheat has a larger acreage in the dry portions of the country than any other winter wheat. The territory in which it is grown is practically the same as that of the Bluestem variety. It is grown very little where the rainfall is heavy. While this wheat is hardy and stands the winter well, many consider it inferior to Fortyfold or Turkey Red in this respect. It shatters very easily, and the heads are long and drooping. The reel slats of the header push many of these drooping heads down and when cut off by the sickle they drop to the ground and are lost. As an export wheat, Fife rates with the Club varieties. It is not their equal as a milling wheat, and its flour is largely used for the export trade. When the Fife freezes out and it is necessary to reseed with the Bluestem variety in the spring some of the Fife wheat usually survives, giving a mixed crop. The mixture sells for Fife prices.

Fortyfold.

Of all the wheats grown in the Columbia Basin few, if any, are better adapted to the entire region than the Fortyfold variety. It stands the winters as well as any wheat grown, with the possible exception of the Turkey Red. The Fortyfold variety is very early, and escapes much of the hot weather in the dry localities that later sorts have to endure. Its earliness is also a great advantage in the eastern portion of the region, where considerable grain is often damaged by the fall rains. Being from 10 to 14 days earlier than other varieties, harvest starts that much sooner. This gives a better chance to care for the grain before the fall rains begin. The Fortyfold variety yields well, but shatters easily. During the past season (1906) this variety sold for the same price as the Bluestem wheat. With but few exceptions the millers who grind this wheat generally agree that it stands between the Little Club and Bluestem varieties in milling qualities.

Turkey Red.

The Turkey Red variety is a hard winter wheat, adapted to about the same territory as Bluestem, i. e., localities with less than 18 inches of rainfall. It probably stands the winters the best of any wheat grown in the Columbia Basin, and unlike most true winter wheats shatters very little. The stems have but little foliage, and for this reason it can be sown thicker than most wheats. When thin on the ground it is inclined to fall, but if thick it stands up quite well. Where the rainfall is more than approximately 18 inches the growth is often too great for the strength of the straw, and it then falls down. However, it is sometimes sown with good results on fall-plowed stubble land. Some object to the Turkey Red variety because it is bearded. Men do not like to work in it. Header horses are usually fed on headed wheat, and the beards make their mouths sore. If the Turkey Red variety is the most profitable wheat to grow, enough of some other variety can be grown to produce feed for the horses.

It is the opinion of experienced growers that the Turkey Red outyields the Jones Fife variety from 4 to 8 bushels to the acre. It is very heavy and seldom tests below No. 1. In milling qualities it stands next to the Bluestem variety. The bran is thin, and some millers say it produces more flour per bushel than the Bluestem wheat. When made from wheat of good quality the flour is of excellent strength, and many of the mills are now grinding it for the bakers' trade. The Turkey Red sold for 1 cent less than the Bluestem variety during the season of 1906.

There is quite a tendency in this wheat for the kernels to become starchy. Perfect kernels are hard, horny, and flinty. When they become yellow they contain less protein and more starch. The cause of this retrogression is not well understood and presents an interesting subject for investigation. For seed it is probably safest to plant wheat containing as few yellow, starchy kernels as possible.

THE PERMANENCY OF THE SINGLE-CROP SYSTEM OF FARMING.

That the wheat lands of the Columbia Basin will produce cereal crops exclusively for an indefinite time without the yields declining is a very general opinion among the farmers of the region. But history is against this opinion. Bountiful harvests for a number of years while the soils were new and then a decline in the yields have been the history of all agricultural regions that have followed a single-crop system. A few examples of this are cited:

Wheat was produced quite successfully in central New York for something like forty years. During the latter part of that period the yields began to decline, and at the end of another twenty years they were so low that exclusive wheat growing became unprofitable.

Ohio, Indiana, Illinois, and Iowa have each in turn repeated the history of New York. The soils of these States were productive in the beginning, and it required forty, fifty, or sixty years for the single-crop system to materially reduce the yields.

But it is not necessary to go to the Eastern States to cite examples of soils whose productiveness has been greatly reduced by the same system of farming that is being practiced in the Columbia Basin. The Willamette Valley, Oregon, was settled about sixty years ago, and until recently wheat was the principal product of the farm. In the beginning large yields were secured, but the soil soon became foul with wild oats and other weeds. The summer-fallow system was then adopted. The yields gradually declined on land that produced wheat continually, until an average as low as 10 or 12 bushels to the acre was reached. These low yields are driving many to other types of farming, and the Willamette Valley now gives promise of becoming one of the leading dairy sections in the United States. The Sacramento Valley, California, is another excellent example. This valley was settled some fifty years ago, and has produced wheat by the summer-fallow system during practically all this time. The yield has steadily declined, until now it is probably as low as 10 bushels per acre.

With due consideration of these examples of agricultural history, how can the wheat lands of the Columbia Basin be expected to maintain their productiveness indefinitely? Are not signs to the contrary manifesting themselves in parts of the country at the present time? Twenty years ago much of the Palouse country gave as large average yields of spring wheat, producing crops every year, as are now secured from winter wheat grown by the summer-fallow system. The virgin soils of the Palouse country and the foothills of the Blue Mountains were mellow and friable, with little inclination to run together. As stated in the foregoing pages in discussing summer fallowing, many farmers think it now necessary to plow the summer fallow so late that the soil will break up in large chunks, this rough, cloddy condition largely preventing the soil from running together during the winter. Now this means simply that this system of farming—summer fallowing and raising nothing but cereal crops—is continually using up the decaying vegetable matter in the soil faster than it is being added. This gradually renders the soil more lifeless and more inclined to run together.

Another source of great loss to the soil is the practice of burning the stubble before plowing. Where the stubble is heavy, it is difficult to plow under, and the easiest way to get rid of it is to burn it. Many farmers do not appreciate the influence decayed vegetable matter (stubble, manure, etc.) has upon the texture and water-holding capacity of the soil. For these reasons these farmers burn their stubble before plowing.

Depleting the soil of its vegetable matter in this way is a slow process, and it is difficult to predict how long it will be until diminished yields force upon the country other types of farming. In the drier localities the yields of wheat seem to be holding up remarkably well. In fact, many claim they have increased. This may be due, first, to better methods of summer-fallow tillage, whereby a greater amount of soil moisture is conserved. In the second place, it may be due to an increase of humus in the soil. The dry soils of the Columbia Basin were not rich in humus when first brought under cultivation. When the grain is cut with a header, all of the straw possible is left upon the ground. It may be that the plowing under of the stubble is adding organic matter to the soil faster than it is being used. At any rate, it is very evident that the drier portions of the Columbia Basin will stand this type of farming much longer than localities near the mountains, where the rainfall is heavier.

CONCLUSIONS.

The best method of summer fallowing in the Columbia Basin consists in disking and harrowing in the early spring before plowing, packing the subsurface immediately after plowing, and following this by sufficient surface cultivation to retain moisture and keep the weeds under control. While this method is not in general use, it is becoming more popular and has been practiced long enough to demonstrate its superior value. Men who practice this method estimate that their yields of wheat are about 25 per cent greater than those obtained by summer fallowing in the ordinary way. The average yield of wheat in the State of Washington during tha year 1906 was 20.4 bushels per acre. This will represent approximately the yield for the Columbia Basin. If it is true that this method increases the yield 25 per cent, the average yield of wheat for the entire region can be raised 5 bushels per acre. By adopting this method of summer fallowing it is possible to retain sufficient moisture throughout much of the semiarid section to germinate wheat at any time it may be sown in the fall. This will make it possible to grow winter wheat over a large area that now produces spring wheat. During the year 1906 the average yield of winter wheat in the State of Washington was 4½ bushels more than that of spring wheat. In addition to increasing the average yield of wheat in the Columbia Basin about 5 bushels per acre, it will be seen that better tillage will further increase the yield 4½ bushels per acre over much of the semiarid section by making it possible to grow winter wheat instead of spring wheat. Hence the importance of the general adoption of this method throughout the Columbia Basin.

In the central portion of the Columbia Basin, where the rainfall is less than 6 inches, wheat can not be successfully produced without irrigation. In extending the area of winter wheat out into the semiarid and arid sections a point will be reached where it will not be possible to conserve sufficient moisture to germinate grain before the fall rains come. When the tillage has been thorough and sufficient moisture has been retained to germinate the seed, the grain is planted quite deeply. When the seed germinates, the young roots are then in contact with moist soil. This enables the young plants to survive until the fall rains come.

Better preparation of the soil for spring crops, especially the use of implements for settling and packing the bottom of the plow furrow, would materially increase the yield of all cereal crops when the land is plowed in the spring before it is sown. During the summer of 1906 the writer saw a field of oats at Grass Valley, Oreg., a portion of which had been packed with a corrugated roller. When seen the oats were nearly ripe. The stand and growth of the oats were very much better upon the rolled portion of the field.

If more intensive methods of tillage are to be adopted, either the size of the farms must be decreased or their equipment increased. Generally speaking, the farmers of the Columbia Basin attempt to till more land than can properly be handled with their equipment.

Too many varieties of wheat are now produced in the Columbia Basin. All of them should be thoroughly tested in the arid, semiarid, and humid sections to determine which are most profitable to grow under the three conditions. The best varieties should then be improved by selection.

The farmers as a whole will secure better results by confining themselves to a few varieties of wheat. Of the spring varieties, the Little Club and the Red Chaff are best adapted to the humid sections and the Bluestem to the arid and semiarid conditions. The Early Wilbur is a new wheat, but gives strong indications of considerable value in the arid section because of its earliness.

Of the winter varieties the Turkey Red easily stands first for the arid and semiarid sections. When the grains are hard and horny it [illegible] milling wheat. On account [illegible] its tendency to [illegible] ly ship in seed [illegible] It stands [illegible] advantage in [illegible] when grown [illegible] very good milling [illegible] Basin, its milling [illegible] itions.

FARMERS' BULLETINS.

The following is a list, by number, of the Farmers' Bulletins available for distribution. The bulletins entitled "Experiment Station Work" give in brief the results of experiments performed by the State experiment stations. Titles of other bulletins are self-explanatory. Bulletins in this list will be sent free to any address in the United States on application to a Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

22. The Feeding of Farm Animals. Pp. 40.
24. Hog Cholera and Swine Plague. Pp. 16.
27. Flax for Seed and Fiber. Pp. 16.
28. Weeds: And How to Kill Them. Pp. 30.
29. Souring and Other Changes in Milk. Pp. 22.
30. Grape Diseases on the Pacific Coast. Pp. 15.
32. Silos and Silage. Pp. 30.
33. Peach Growing for Market. Pp. 24.
34. Meats: Composition and Cooking. Pp. 31.
35. Potato Culture. Pp. 24.
36. Cotton Seed and Its Products. Pp. 16.
42. Facts about Milk. Pp. 32.
44. Commercial Fertilizers. Pp. 38.
47. Insects Affecting the Cotton Plant. Pp. 32.
48. The Manuring of Cotton. Pp. 16.
51. Standard Varieties of Chickens. Pp. 48.
52. The Sugar Beet. Pp. 48.
54. Some Common Birds. Pp. 48.
55. The Dairy Herd. Pp. 30.
56. Experiment Station Work—I. Pp. 30.
58. The Soy Bean as a Forage Crop. Pp. 24.
59. Bee Keeping. Pp. 48.
60. Methods of Curing Tobacco. Pp. 24.
61. Asparagus Culture. Pp. 40.
62. Marketing Farm Produce. Pp. 31.
63. Care of Milk on the Farm. Pp. 40.
64. Ducks and Geese. Pp. 55.
65. Experiment Station Work—II. Pp. 32.
66. Meadows and Pastures. Pp. 30.
69. Experiment Station Work—III. Pp. 32.
71. Essentials in Beef Production. Pp. 24.
72. Cattle Ranges of the Southwest. Pp. 32.
73. Experiment Station Work—IV. Pp. 32.
74. Milk as Food. Pp. 39.
77. The Liming of Soils. Pp. 24.
78. Experiment Station Work—V. Pp. 32.
79. Experiment Station Work—VI. Pp. 27.
80. The Peach Twig-Borer. Pp. 16.
81. Corn Culture in the South. Pp. 24.
82. The Culture of Tobacco. Pp. 22.
83. Tobacco Soils. Pp. 23.
84. Experiment Station Work—VII. Pp. 32.
85. Fish as Food. Pp. 32.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
91. Potato Diseases and Treatment. Pp. 15.
92. Experiment Station Work—IX. Pp. 30.
93. Sugar as Food. Pp. 31.
95. Good Roads for Farmers. Pp. 46.
97. Experiment Station Work—X. Pp. 32.
98. Suggestions to Southern Farmers. Pp. 48.
99. Insect Enemies of Shade Trees. Pp. 30.
100. Hog Raising in the South. Pp. 40.
101. Millets. Pp. 30.
102. Southern Forage Plants. Pp. 48.
103. Experiment Station Work—XI. Pp. 30.
104. Notes on Frost. Pp. 24.
105. Experiment Station Work—XII. Pp. 32.
106. Breeds of Dairy Cattle. Pp. 48.
107. Experiment Station Work—XIII. Pp. 32.
108. Saltbushes. Pp. 20.
110. Rice Culture in the United States. Pp. 28.
111. Farmers' Interest in Good Seed. Pp. 24.
112. Bread and Bread Making. Pp. 40.
113. The Apple and How to Grow It. Pp. 32.
114. Experiment Station Work—XIV. Pp. 28.
116. Irrigation in Fruit Growing. Pp. 48.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 30.
120. Insects Affecting Tobacco. Pp. 32.
121. Beans, Peas, and Other Legumes as Food. Pp. 38.
122. Experiment Station Work—XVI. Pp. 32.
124. Experiment Station Work—XVII. Pp. 32.
125. Protection of Food Products from Injurious Temperatures. Pp. 24.
126. Practical Suggestions for Farm Buildings. Pp. 48.
127. Important Insecticides. Pp. 46.
128. Eggs and Their Uses as Food. Pp. 40.
129. Sweet Potatoes. Pp. 40.
131. Household Tests for Detection of Oleomargarine and Renovated Butter. Pp. 10.
132. Insect Enemies of Growing Wheat. Pp. 38.
133. Experiment Station Work—XVIII. Pp. 32.
134. Tree Planting in Rural School Grounds. Pp. 32.
135. Sorghum Sirup Manufacture. Pp. 40.
137. The Angora Goat. Pp. 48.
138. Irrigation in Field and Garden. Pp. 40.
139. Emmer: A Grain for the Semiarid Regions. Pp. 16.
140. Pineapple Growing. Pp. 48.
142. Principles of Nutrition and Nutritive Value of Food. Pp. 48.
144. Experiment Station Work—XIX. Pp. 32.
145. Carbon Bisulphid as an Insecticide. Pp. 28.
147. Winter Forage Crops for the South. Pp. 40.
149. Experiment Station Work—XX. Pp. 32.
150. Clearing New Land. Pp. 24.
151. Dairying in the South. Pp. 48.
152. Scabies in Cattle. Pp. 32.
153. Orchard Enemies in the Pacific Northwest. Pp. 39.
154. The Home Fruit Garden: Preparation and Care. Pp. 16.
155. How Insects Affect Health in Rural Districts. Pp. 19.
156. The Home Vineyard. Pp. 22.
157. The Propagation of Plants. Pp. 24.
158. How to Build Small Irrigation Ditches. Pp. 28.
159. Scab in Sheep. Pp. 48.
161. Practical Suggestions for Fruit Growers. Pp. 30.
162. Experiment Station Work—XXI. Pp. 32.
164. Rape as a Forage Crop. Pp. 16.
165. Silkworm Culture. Pp. 32.
166. Cheese Making on the Farm. Pp. 16.
167. Cassava. Pp. 32.
168. Pearl Millet. Pp. 16.
169. Experiment Station Work—XXII. Pp. 32.
170. Principles of Horse Feeding. Pp. 44.
172. Scale Insects and Mites on Citrus Trees. Pp. 43.
173. Primer of Forestry. Pp. 48.
174. Broom Corn. Pp. 30.
175. Home Manufacture and Use of Unfermented Grape Juice. Pp. 16.
176. Cranberry Culture. Pp. 20.
177. Squab Raising. Pp. 32.
178. Insects Injurious in Cranberry Culture. Pp. 32.
179. Horseshoeing. Pp. 30.
181. Pruning. Pp. 39.
182. Poultry as Food. Pp. 40.
183. Meat on the Farm: Butchering, Curing, and Keeping. Pp. 37.
185. Beautifying the Home Grounds. Pp. 24.
186. Experiment Station Work—XXIII. Pp. 32.
187. Drainage of Farm Lands. Pp. 38.
188. Weeds Used in Medicine. Pp. 45.
190. Experiment Station Work—XXIV. Pp. 32.
192. Barnyard Manure. Pp. 32.
193. Experiment Station Work—XXV. Pp. 32.

194. Alfalfa Seed. Pp. 14.
195. Annual Flowering Plants. Pp. 48.
196. Usefulness of the American Toad. Pp. 16.
197. Importation of Game Birds and Eggs for Propagation. Pp. 30.
198. Strawberries. Pp. 24.
199. Corn Growing. Pp. 32.
200. Turkeys. Pp. 40.
201. Cream Separator on Western Farms. Pp. 23.
202. Experiment Station Work—XXVI. Pp. 32.
203. Canned Fruits, Preserves, and Jellies. Pp. 32.
204. The Cultivation of Mushrooms. Pp. 24.
206. Milk Fever and Its Treatment. Pp. 16.
208. Varieties of Fruits Recommended for Planting. Pp. 48.
209. Controlling the Boll Weevil in Cotton Seed and at Ginneries. Pp. 32.
210. Experiment Station Work—XXVII. Pp. 32.
211. The Use of Paris Green in Controlling the Cotton Boll Weevil. Pp. 23.
213. Raspberries. Pp. 38.
215. Alfalfa Growing. Pp. 40.
217. Essential Steps in Securing an Early Crop of Cotton. Pp. 16.
218. The School Garden. Pp. 40.
219. Lessons from the Grain Rust Epidemic of 1904. Pp. 24.
220. Tomatoes. Pp. 32.
221. Fungous Diseases of the Cranberry. Pp. 16.
222. Experiment Station Work—XXVIII. Pp. 32.
223. Miscellaneous Cotton Insects in Texas. Pp. 24.
224. Canadian Field Peas. Pp. 16.
225. Experiment Station Work—XXIX. Pp. 32.
226. Relation of Coyotes to Stock Raising in the West. Pp. 24.
227. Experiment Station Work—XXX. Pp. 32.
228. Forest Planting and Farm Management. Pp. 22.
229. The Production of Good Seed Corn. Pp. 24.
231. Spraying for Cucumber and Melon Diseases. Pp. 24.
232. Okra: Its Culture and Uses. Pp. 16.
233. Experiment Station Work—XXXI. Pp. 32.
234. The Guinea Fowl. Pp. 24.
235. Preparation of Cement Concrete. Pp. 32.
236. Incubation and Incubators. Pp. 32.
237. Experiment Station Work—XXXII. Pp. 32.
238. Citrus Fruit Growing in the Gulf States. Pp. 48.
239. The Corrosion of Fence Wire. Pp. 32.
241. Butter Making on the Farm. Pp. 32.
242. An Example of Model Farming. Pp. 16.
243. Fungicides and Their Use in Preventing Diseases of Fruits. Pp. 32.
244. Experiment Station Work—XXXIII. Pp. 32.
245. Renovation of Worn-Out Soils. Pp. 16.
246. Saccharine Sorghums for Forage. Pp. 37.
247. The Control of the Codling Moth and Apple Scab. Pp. 21.
248. The Lawn. Pp. 20.
249. Cereal Breakfast Foods. Pp. 36.
250. The Prevention of Wheat Smut and Loose Smut of Oats. Pp. 16.
251. Experiment Station Work—XXXIV. Pp. 32.
252. Maple Sugar and Sirup. Pp. 36.
253. The Germination of Seed Corn. Pp. 16.
254. Cucumbers. Pp. 30.
255. The Home Vegetable Garden. Pp. 47.
256. Preparation of Vegetables for the Table. Pp. 18.
257. Soil Fertility. Pp. 39.
258. Texas or Tick Fever and Its Prevention. Pp. 45.
259. Experiment Station Work—XXXV. Pp. 32.
260. Seed of Red Clover and Its Impurities. Pp. 24.
261. The Cattle Tick. Pp. 22.
262. Experiment Station Work—XXXVI. Pp. 32.
263. Practical Information for Beginners in Irrigation. Pp. 40.
264. The Brown-Tail Moth and How to Control It. Pp. 22.
266. Management of Soils to Conserve Moisture. Pp. 30.
267. Experiment Station Work—XXXVII. Pp. 32.
268. Industrial Alcohol: Sources and Manufacture. Pp. 45.
269. Industrial Alcohol: Uses and Statistics. Pp. 29.
270. Modern Conveniences for the Farm Home. Pp. 48.
271. Forage Crop Practices in Western Oregon and Western Washington. Pp. 39.
272. A Successful Hog and Seed-Corn Farm. Pp. 16.
273. Experiment Station Work—XXXVIII. Pp. 32.
274. Flax Culture. Pp. 36.
275. The Gipsy Moth and How to Control It. Pp. 22.
276. Experiment Station Work—XXXIX. Pp. 32.
277. The Use of Alcohol and Gasoline in Farm Engines. Pp. 40.
278. Leguminous Crops for Green Manuring. Pp. 27.
279. A Method of Eradicating Johnson Grass. Pp. 16.
280. A Profitable Tenant Dairy Farm. Pp. 16.
281. Experiment Station Work—XL. Pp. 32.
282. Celery. Pp. 36.
283. Spraying for Apple Diseases and the Codling Moth in the Ozarks. Pp. 42.
284. Insect and Fungous Enemies of the Grape East of the Rocky Mountains. Pp. 48.
285. The Advantage of Planting Heavy Cotton Seed. Pp. 16.
286. Comparative Value of Whole Cotton Seed and Cotton-Seed Meal in Fertilizing Cotton. Pp. 14.
287. Poultry Management. Pp. 48.
288. Nonsaccharine Sorghums. Pp. 28.
289. Beans. Pp. 28.
290. The Cotton Bollworm. Pp. 32.
291. Evaporation of Apples. Pp. 38.
292. Cost of Filling Silos. Pp. 15.
293. Use of Fruit as Food. Pp. 38.
294. Farm Practice in the Columbia Basin Uplands. Pp. 30.
295. Potatoes and Other Root Crops as Food. Pp. 45.
296. Experiment Station Work—XLI. Pp. 32.
297. Method of Destroying Rats. Pp. 8.
298. The Food Value of Corn and Corn Products. Pp. 40.
299. Diversified Farming Under the Plantation System. Pp. 14.
300. Some Important Grasses and Forage Plants for the Gulf Coast Region. Pp. 15.
301. Home-Grown Tea. Pp. 16.
302. Sea Island Cotton: Its Culture, Improvement, and Diseases. Pp. 48.
303. Corn Harvesting Machinery. Pp. 32.
304. Growing and Curing Hops. Pp. 39.
305. Experiment Station Work—XLII. Pp. 32.
306. Dodder in Relation to Farm Seeds. Pp. 27.
307. Roselle: Its Culture and Uses. Pp. 16.
308. Game Laws for 1907. Pp. 52.
309. Experiment Station Work—XLIII. Pp. 32.
310. A Successful Alabama Diversification Farm. Pp. 24.
311. Sand-Clay and Burnt-Clay Roads. Pp. 20.
312. A Successful Southern Hay Farm. Pp. 15.
313. Harvesting and Storing Corn. Pp. 32.
314. A Method of Breeding Early Cotton to Escape Boll-Weevil Damage. Pp. 24.
315. Progress in Legume Inoculation. Pp. 20.
316. Experiment Station Work—XLIV. Pp. 32.
317. Experiment Station Work—XLV. Pp. 32.
318. Cowpeas. Pp. 26.
319. Demonstration Work in Cooperation with Southern Farmers. Pp. 23.

O

997 Issued June 18, 1907.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 295.

POTATOES AND OTHER ROOT CROPS AS FOOD.

BY

C. F. LANGWORTHY, Ph. D.,
In Charge of Nutrition Investigations, Office of Experiment Stations.

PREPARED UNDER THE SUPERVISION OF THE OFFICE OF EXPERIMENT STATIONS,
A. C. TRUE, Director.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., April 24, 1907.

Sir: In connection with the nutrition investigations of the Office of Experiment Stations, a number of studies have been made of the nutritive value and digestibility of potatoes and other root crops and the losses which such foods sustain when cooked in different ways. Many analyses of such foods have been made and other questions connected with their place in the diet and their most economical use in the home have received attention at several of the agricultural experiment stations.

The results of such investigations and the general information available in scientific journals and other works of reference have been summarized in the preparation of the present article on potatoes and other root crops used as food, by C. F. Langworthy, in charge of Nutrition Investigations of this Office, which I have the honor to transmit herewith and recommend for publication as a Farmers' Bulletin.

The article is similar in purpose to other popular summaries which have appeared in this series of bulletins. The section which concerns potatoes is a revision and extension of an article by Doctor Langworthy, published in the Yearbook of the Department for 1900.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.

- Introduction 5
- Potatoes 7
  - History and extent of cultivation 7
  - Structure and composition 8
  - Cooking 13
  - Dried or evaporated potatoes and canned potatoes 17
  - Storage: Its effect on quality 18
  - Possible dangers from eating potatoes 19
  - Marks of good potatoes 20
  - Digestibility of potatoes 21
  - Place of potatoes in the diet 22
- Cetewayo, or Zulu potatoes 23
- Sweet potatoes 23
  - Composition and nutritive value 25
  - Dried and canned sweet potatoes 27
  - Digestibility and place in the diet 27
- The Jerusalem artichoke 28
- Stachys 29
- Tropical starch-bearing roots 29
  - Cassava 30
  - Taro 31
  - Yautia 31
  - Yams 32
- Succulent roots, tubers, and bulbs 32
  - Beets 34
  - Celeriac 35
  - Carrots 36
  - Parsnips 37
  - Salsify 38
  - Radishes 38
  - Turnips 39
  - Kohl-rabi 39
  - Onions, garlic, etc 40
- Roots used as condiments 41
- Summary 42

POTATOES AND OTHER ROOT CROPS AS FOOD.

INTRODUCTION.

Among the products of the vegetable kingdom used for human food the cereals are undoubtedly the most important, but next to them must be placed the group of plants which during the favorable days of summer lay up for themselves a supply of reserve material in thickened roots or underground stems and bulbs. These plants belong to many different groups and have different habits and varied appearance, but from the standpoint of food value their common characteristic of producing underground parts filled with nutritious material makes it convenient and logical to group them together. In some cases it is a true root, such as the beet, in which the plant lays up its store; in others it is an underground stem as in the case of tubers like the potato, and again it is a bulb like the onion. Botanically, these distinctions are very important, but they have little bearing on the food value, and for the present purpose it is sufficiently accurate to speak of all such vegetables as "root crops."

These edible tuberous bulbs and roots divide themselves roughly into two main classes: Those in which the plant stores its food principally in the form of insoluble starch, and those in which a comparatively large proportion is in the form of sugar or some other soluble bodies. As a general rule vegetables of the latter group contain a larger proportion of water than the starchy tubers, etc., and are therefore often called the succulent roots.

Of the starchy group, the common potato is by far the most important as regards both its nutritive value and the extent of its cultivation. In the United States the sweet potato ranks next to it. What a prominent place these two together hold in the diet may be seen from the fact that in the average of 376 American dietary studies they were found to furnish 12.5 per cent, or about one-eighth of the total food material, and 8.3 per cent, or about one-twelfth of the carbohydrates. All other vegetables together furnished only 7.8 per cent of the total food and 3.7 per cent of the carbohydrates. There are no starchy tubers or roots except these in general use in this country, though a few are frequently seen in city markets. In other parts of the world, especially in eastern Asia and the Tropics, others to a large extent occupy the place which potatoes hold in Europe and America.

The succulent roots are less important as human food than the starchy ones. Beets, carrots, parsnips, turnips, and onions are the most common. Many of them are characterized by strong flavors and odors due to volatile oils which they contain. Like potatoes, they can be stored for months without serious deterioration, and being comparatively low-priced occupy an important place in the list of winter vegetables. Some highly flavored roots, such as the horseradish and ginger, serve mainly as condiments, their food value in the quantities in which they are used being too small to be of any practical importance.

The tubers and root vegetables may roughly be said to contain from 70 to 90 per cent water and from 10 to 30 per cent solid material. By far the greater part of the solid matter occurs in some form or forms of carbohydrates. There are also small quantities of nitrogenous substances, and, compared with most food materials, considerable quantities of mineral matters or ash, especially in the succulent roots. From this it will be seen that even the least watery of these vegetables is far from supplying the body with all that it needs. The carbohydrates furnish it with excellent fuel for keeping up its warmth and supplying it with energy needed for muscular activity. The ash and the various compounds which give flavor supply the needed mineral matters and stimulate the action of the digestive organs, but protein or nitrogenous material, which is indispensable in the building and repair of muscular tissue, is in most varieties nearly lacking, and in no case is it in the right proportion to nonnitrogenous material to serve for the best bodily development. Much is said about the Irish peasant and his potato diet and how well he can live and work on this fare, but in almost every case he keeps a cow along with his potato patch, and the abundance of milk in his diet furnishes him with a fair amount of protein. There is every reason to believe that among the tropical races, who are supposed to live mainly on the starchy roots and similar foods, there are some such sources of protein in the diet which general observers have overlooked. For instance, few travelers who write of the general use of rice in the Orient realize the importance of the nitrogenous soy-bean products so extensively used in China and Japan, or the milk, milk products, pulse, or legumes, and similar foods used in India. It is in connection with other materials richer in protein that the edible tubers and roots find their true place in the diet.

The potato so far surpasses all other tubers and roots in importance that its composition and nutritive value have been carefully studied both in this country and in Europe. It will, therefore, be discussed in detail and in a measure considered as a type of all the other tubers and roots, especially the starchy group.

POTATOES.

HISTORY AND EXTENT OF CULTIVATION.

The potato, called in different regions white potato, Irish potato, English potato, or round potato, was first introduced into Europe between 1580 and 1585 by the Spaniards, and afterwards by the English about the time of the expeditions sent by Raleigh to the Virginia country. It is believed to be a native of Chile, where a wild plant is still found which much resembles it. A similar tuber, known as the Cetewayo potato, is also eaten by the natives in some districts of South Africa. When first visited by Europeans, the aborigines in Chile and adjacent regions cultivated the potato for its edible tubers and had apparently long done so. It was probably introduced into the United States, especially into Virginia and North Carolina, toward the end of the sixteenth century. In spite of its easy cultivation, rich yield, and pleasant flavor, the potato did not receive a warm welcome when first introduced into Europe. For a long time there was a popular belief that it was poisonous, perhaps because botanically it is related to the deadly nightshade, and for years it was cultivated mainly as a garden curiosity. During the second half of the eighteenth century, however, came a series of bad harvests in some of the staple food crops throughout Europe and the potato quickly rose into almost universal prominence. Since then its use has constantly increased, for it is one of the cheapest vegetables to raise, can be kept over the winter, is easy to prepare for the table, pleasant in taste, and very rich in digestible starch. It soon became a staple food among all classes throughout central and northern Europe, so that when in the middle of the last century the black rot wrought its deadly havoc on the crops not only Ireland but large districts in continental Europe also were seriously threatened with famine. Next to the breadstuffs it is undoubtedly the most important food crop of the western nations.

According to the last United States census, 273,318,167 bushels were raised in this country in 1899, representing 40.7 per cent of the total vegetable crop, and valued at $98,380,110. Of course, part of the total crop is used for animal fodder and a part for various manufactured articles, but the proportion thus used is probably small, and includes mainly inferior grades of tubers. The principal article manufactured from potatoes is starch, which, until cornstarch supplanted it, was quite largely used in cooking, but now is mainly employed for making sizing for paper and textiles and for other technical purposes. Potato starch has also been sometimes found as an adulterant of fine flours and starches. Much of our commercial glucose is made from potatoes, and they are also an important source of alcohol, especially in Europe.

It is a fact worthy of mention that, as the potato has been modified by cultivation, it has largely lost the power of producing seeds, and the cultivated potato differs from the wild in seldom producing seed-bearing fruits. This is a disadvantage from the plant-breeder's standpoint, as he depends on seed from blossoms properly fertilized to yield new varieties. From the grower's standpoint it is of little moment, as he always uses the old tubers in planting the potato crop, each "eye" in the potato being a bud on the underground stem which is capable of growing into a new plant.

The potato is grown in practically all parts of the United States, but most abundantly in the North Atlantic and North Central States. Within recent years its culture has been greatly developed throughout the sandy pine tracts just south of the Canadian boundary, and local experiment stations have given great aid and encouragement to the work. The South Atlantic States furnish a considerable proportion of the crop, but mainly in the form of high-priced early potatoes for city markets.

STRUCTURE AND COMPOSITION.

The potato tuber, as has been said, is in reality a modified stem, being shortened and thickened as a storehouse for material held in reserve for the early growth of new plants. The outer skin of the tuber consists of a thin, grayish brown corky substance and corresponds roughly to the bark of an overground stem. If a crosswise section of a raw potato is held up to the light three distinct parts besides the skin may be seen. The outermost one is known as the cortical layer and may be from 0.12 to 0.5 inch in thickness. This layer is slightly colored, the tint varying with the kind, and turns green if exposed to the light for some time, thus showing its relation to the tender green layer beneath the bark of overground stems. It is denser than the other parts of the potato and contains many fibrovascular bundles, especially on the inner edge where a marked ring of them plainly separates this layer from the next. The interior or flesh of the tuber is made up of two layers known as the outer and inner medullary areas. The outer one forms the main bulk of a well-developed potato and contains the greater part of the food ingredients. The inner medullary area, sometimes called the core, appears in a cross section of the tuber to spread irregular arms up into the outer, so that its outline roughly suggests a star. It contains slightly more cellulose and less water and nutrients than the outer medullary portion. These four parts of the tuber are shown in figure 1.

As in all other plant forms, the framework of the tuber is made up of cellulose, a carbohydrate or group of carbohydrates familiar in many forms, as, for instance, the fiber of cotton or linen or the bran of wheat. In food and feeding stuff analyses it is usually designated crude fiber. Cellulose forms the walls of a network of cells, which in turn form the body of the tuber. These cells vary in shape and size in different sections of the tuber according to the part they play in its life. In the flesh they serve mainly for storage, and in them lie the starch grains. (See fig. 3*a*.)

The interior of the tuber is more or less permeated by water in which are dissolved nearly all the soluble ingredients, including the various soluble carbohydrates,[a] mineral matters, and soluble proteid bodies.

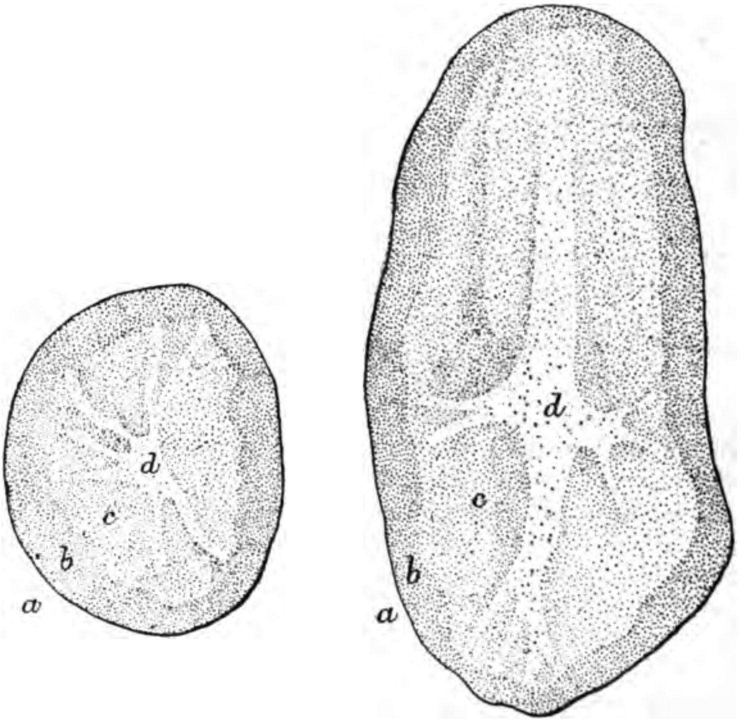


FIG. 1.—Transverse and longitudinal sections of the potato: *a*, skin; *b*, cortical layer; *c*, outer medullary layer; *d*, inner medullary area.

Cultural varieties of a given plant often have very different habits, appearance, and quality, and it is natural that the amounts and proportions of water, carbohydrates, fats, protein, and mineral matters which the potato contains should vary with the variety as well as with the character of the soil, the climate, and other conditions under which it grows. Moreover, since the needs of the potato plant vary at different stages of its developement, it will provide for them by varying the ingredients stored in the tubers and elsewhere. Taking into account all these factors, it might seem impossible to make any general statements about the chemical composition of the potato, but it may be said that the variations are in degree rather than in kind, and so many analyses and studies have been made, both in this country and in Europe, that the average or general characteristics of the potato are now well established. The figures in Table 1 show the composition of raw and cooked potatoes and represent the average of many American analyses. For comparison the composition of white bread is also given.

---

[a] In this connection it is well to recall that the carbohydrates (cellulose, starch, the different kinds of sugars, etc.) are all closely related, and that under the influence of certain acids, heat, or other agency an insoluble form, such as starch, may be changed into a soluble form, or vice versa.

TABLE 1.—*Composition of raw and cooked potatoes.*

Kind of food.	Refuse.	Water.	Protein.	Fat.	Carbohydrates.		Ash.	Fuel value per pound.
					Sugar, starch, etc.	Crude fiber.		
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Potato, as purchased	20.0	62.6	1.8	0.1	13.8	0.9	0.8	310
Potato, edible portion		78.3	2.2	.1	18.0	.4	1.0	375
Potato, boiled		75.5	2.5	.1	20.3	.6	1.0	440
Potato, mashed and seasoned		75.1	2.6	3.0	17.8		1.5	505
Potatoes fried in fat, "Potato chips"		2.2	6.8	39.8	46.7		4.5	2,675
Potato, evaporated		7.1	8.5	.4	80.9		3.1	1,680
White bread		35.3	9.2	1.3	52.6	.5	1.1	1,215

The corky skin of the potato makes up about 2.5 per cent of the whole, and the cortical layer 8.5 per cent, leaving 89 per cent for the medullary areas. Theoretically, the skin is the only refuse or inedible material in the potato, but in practice a considerable part of the cortical layer is usually removed with it. When the surface is irregular or lumpy or the tubers have shriveled in storage, a much greater proportion of the flesh is likely to be cut off with the skin in peeling than is the case when the tubers are smooth and in good condition. When potatoes are baked or boiled in their jackets, more or less of the flesh is wasted when the skin is removed, and in this case also the amount bears some relation to the shape of the tubers. Just how much such a loss of edible portion averages it is hard to say. In connection with the nutrition investigations of this Department, it was estimated that in peeling raw potatoes the loss was about 20 per cent, which would include not only all of the skin and the cortical layer, but also 9 per cent from the flesh. When we recall how large is the proportion of water and how low that of nutrients in the tuber, and also that the larger proportion of the valuable protein and mineral matters is in the outer layers, this waste appears more important than is generally realized.

The edible portion of the potato, i. e., the tuber without the corky skin, holds on an average about 78 per cent water, and so only about

20 per cent of the whole tuber has a direct food value. Figure 2 represents the composition of the potato in graphic form and shows the proportion usually wasted when it is boiled.

This diagram shows very plainly that the bulk of the potato tuber is water. The stage of growth and other conditions affect the proportion present, young tubers being more juicy or watery than those which are fully developed. When potatoes are stored, they undergo a shrinkage chiefly owing to loss of water or juice by evaporation. According to tests made at the Michigan Agricultural Experiment Station this loss amounted to 11.5 per cent when they were kept in storage from September 30 to May 1.

The carbohydrates are by far the most abundant of the nutrients. Of the 18.4 per cent present less than 0.5 per cent is made up of cellulose, yet one sometimes hears the statement made that potatoes are indigestible on account of the large quantities of cellulose which they contain. In reality there is as much or more in almost all the cereals and other vegetable foods, and such a criticism of the potato has no warrant of fact.

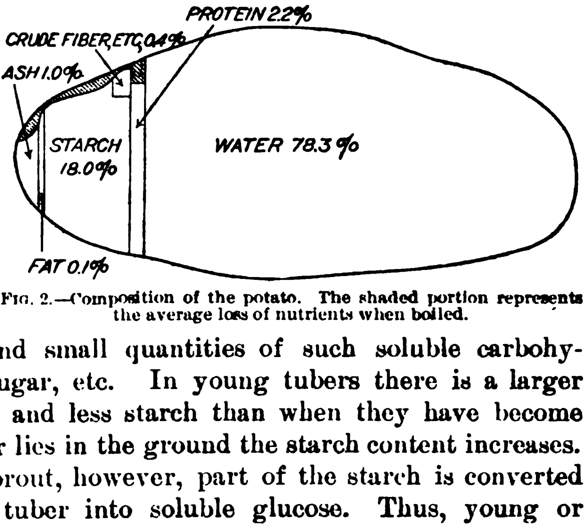


FIG. 2.—Composition of the potato. The shaded portion represents the average loss of nutrients when boiled.

The bulk of the carbohydrates which the potato stores for future use is in the form of starch, which is, of course, insoluble in cold water, and small quantities of such soluble carbohydrates as dextrose, sugar, etc. In young tubers there is a larger proportion of sugars and less starch than when they have become mature. As the tuber lies in the ground the starch content increases. When it begins to sprout, however, part of the starch is converted by a ferment in the tuber into soluble glucose. Thus, young or early potatoes and old ones both have a smaller proportion of starch and more soluble sugars than well-grown but still fresh tubers. If the grated potato is mixed with water starch falls out from the broken cells and settles to the bottom of the vessel, and may be removed in the form of a white deposit. Starch is manufactured to a large extent from potatoes by methods which are similar to the above in principle.[a]

Other carbohydrates in the potato are the so-called pectose bodies, the substances which cause fruit jellies to stiffen, and when the tubers are large and pulpy pectoses may make up 4 per cent of the tuber, though they usually occur in much smaller quantities. They are believed to have about the same food value as starch.

---

[a] For an extended account of the manufacture of starch from potatoes, see U. S. Dept. Agr., Bur. Chem. Bul. 58.

Fat, or ether extract, appears in such small quantities in potatoes that it may be practically neglected in discussing their food value, especially as the greater part occurs in the inedible skin in the form of a wax-like body.

The protein bodies are rather scanty, as compared with those of cereals and such vegetables as peas and beans. Only about 60 per cent of the total amount present is true protein—that is, in a form which can be used for the building and repair of body tissue. This means that a pound of potatoes furnishes only about 1.3 per cent or 0.2 of an ounce of true protein, and emphasizes the statement already made that potatoes alone make a very incomplete diet, as the proportion of nitrogenous material would be very small in a quantity sufficient to supply the body with all the energy-yielding material required.

These potato proteids have been studied by the Connecticut Experiment Station and found to consist of a form of globulin, for which the name "tuberin" is suggested, and a proteose, part of these nitrogenous constituents being dissolved in the juice and part stored with the starch in the cells, especially in the cortical layer.

The nonproteid forms of nitrogenous substances in the potato are asparagin and small quantities of amido acids, occurring mostly in the juice. If they have any food value it is indirect and due to the fact that they protect the true proteids from waste during digestion. It is possible that they may aid digestion in some way or serve a similar purpose. There is a larger proportion of protein compounds, and especially of the more soluble forms, in young potatoes than in old.

The most important mineral matters found in potatoes are potash and phosphoric acid compounds. There are several organic acids (as citric, tartaric, and succinic acid), which vary in tubers of different ages and account in some measure for the flavor of potatoes. (See also p. 19.)

If peeled potatoes are exposed to the air the outer surface turns brown, just as does the flesh of many fruits. Such change is due to the action of enzyms or unorganized ferments naturally present in the plants. In the presence of the oxygen of the air they work upon tannin-like bodies in the tuber or fruit in such a way that the latter change color. In the case of potatoes this browning may be prevented by putting the peeled tubers into salted water or even into cold plain water.

In the condition in which they are purchased potatoes resemble such succulent carbohydrate foods as turnips and beets, with an average water content of 90 per cent, more than they do such dry carbohydrate foods as flour or rice, with an average of 12 per cent. The condition in which foods are eaten should also be taken into account, for if the value of a food is judged solely by its chemical composition as it is found in the market a wrong impression may be obtained. For instance, potatoes as purchased consist of one-fifth and rice of seven-eighths nutritive material. The first inference is that rice is more than four times as nutritious as potatoes. In one sense this is true—that is to say, a pound of uncooked rice contains more than four times as much nutritive material as a pound of raw potatoes. But if we take about 4 pounds of potatoes—that is, the amount necessary to furnish as much nutritive material as the pound of rice—the composition and nutritive value of the two quantities will be just about the same, while from a pecuniary standpoint the advantage would be on the side of the potatoes. The chief difference in the two foods before cooking is that one is juicy and bulky, while the other is dry, and therefore more concentrated. In cooking rice we mix water with it, and may thus make a material not very different in composition from potatoes. By drying potatoes they can be made very similar in composition and food value to rice. Considering the two articles as ordinarily purchased, 4.5 pounds of raw potatoes and a pound of uncooked rice contain nearly equal weights of each class of nutrients and have about the same nutritive value.

COOKING.

In cooking, the heat affects the various constituents of the potato in different ways. The water expands into steam, part of which evaporates from the surface. Within the minute cells making up the tuber it presses so hard against the walls that the tough cellulose is ruptured just as any air-tight vessel may be broken by the pressure of expanding steam. The starch grains inside the cells are thus released, some of them being also disintegrated, while part are changed into the soluble form of dextrin by the heat and part are filled with water or hydrated. The protein coagulates or hardens much as the white of egg does in boiling, and at least a part of it is broken down into simpler bodies. The mineral salts are probably little affected, but some of them are broken down, part of their constituents passing off as gases and part forming new compounds with quite different characteristics. It is the sum of these and minor changes which make the difference between a raw and a cooked potato. As may be seen from the figures in Table 1, the cooked potatoes which contain no added fat or other material do not differ much from the raw as regards composition. The effect of cooking on the mechanical condition of the potato cells is shown in figure 3.

The figures show the great changes in the mechanical condition of the potato flesh under the influence of heat, the broken cell walls and the increased bulk of the starch grains being particularly noticeable.

The mealy, soft, porous, cooked potato is in a favorable condition for the action of the digestive juices, as moisture readily penetrates to all parts of it, while this is not the case with the raw and rather tough flesh of the uncooked tuber. It is commonly said that raw starch, like that found in the potato, is not digestible, but later investigations indicate that this is not the case and that the digestive juices will dissolve the starch, provided the cell walls are ruptured so that the ferments may come in contact with it. The fact that some of the starch may be changed to soluble bodies under the influence of heat in cooking is an advantage rather than the reverse from the standpoint of digestion.

One of the great advantages in cooking potatoes and similar vegetable foods is the improvement in flavor. Raw potatoes, especially old ones, often have a decidedly bitter and disagreeable flavor (see p. 20), which is less marked after cooking, as some of the flavor-yielding bodies are volatilized or are extracted. The flavor of the cooked potato is also due in part to the development of the cooked-starch taste, which is much more pleasant than that of raw starch.

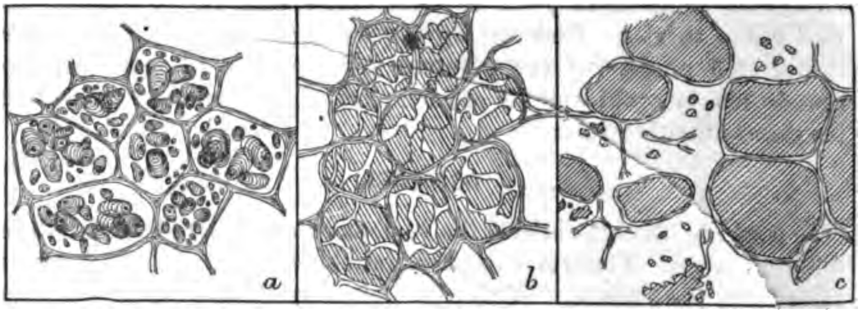


FIG. 3.—Changes of starch cells in cooking: *a*, cells of a raw potato with starch grains in natural condition; *b*, cells of a partially cooked potato; *c*, cells of a thoroughly boiled potato.

There are also disadvantages in the results of cooking, and though on the whole they are much less important than the advantages nevertheless they influence the food value. There is some reason for believing that the protein of the potato when stiffened by heat is less easily digested than when raw. A much more serious matter is that considerable quantities of the nutrients may be lost from the potato during cooking. So important is this point that at the Connecticut and Minnesota experiment stations several series of experiments have been made to determine just how much of the various nutrients is thus lost when the potatoes are cooked in various ways. In some of the tests distilled water and in others limewater and alkaline water were used, but the quality of the water seemed to have little influence on the loss. In other experiments some of the potatoes were soaked for several hours before boiling, and it was found that this tripled the proportion of protein lost and doubled that of the ash. If the potatoes were put into cold water at the start, it was found that they lost almost twice as much protein (15.8 per cent) as when they were plunged at once into boiling water (8.2 per cent). With the cold they lost 18.8 per cent of their ash and with the hot water practically the same amount. It has been suggested that the difference in the amount of protein removed is due to the fact that when the potato is plunged into boiling water the protein near the surface hardens at once and hinders the escape of juices from the interior. When, on the other hand, it is heated slowly much of the juice soaks out before the protein coagulates. On account of these losses in boiling potatoes many persons consider steaming preferable. (See p. 11.)

The tests just described were all made with peeled potatoes, but another series was made with unpeeled ones in which it was found that when boiled in their jackets potatoes lost only 1 per cent of their protein and a little over 3 per cent of their ash, no matter what the temperature of the water was at the start. Almost no starch is removed when potatoes are boiled in their skins, but when peeled the mechanical action of the boiling water wears off the outer surface and in this way as much as 3 per cent of the carbohydrates may be lost.

Evidently, then, by far the most economical way to boil potatoes is in their jackets. When they are cooked this way they should, of course, be thoroughly scraped before boiling and it is a common practice to remove a section of the skin at each end of the potato or to pare a ring around the middle of the tuber so that the moisture may escape and the cooked potato may not become soggy on standing. If they are peeled before cooking they should be placed directly in hot water.

When baked in their skins potatoes probably undergo much the same changes as in boiling, save that they lose practically none of their ingredients except a little water which evaporates through the skin. Some of their moisture changes to steam inside, and unless the potatoes are to be eaten immediately this must be allowed a way of escape through a break or holes made with a fork in the skin, or it will change back to water and make the potato soggy.

When raw potatoes are fried they should be cut into small pieces in order that the heat may penetrate to the interior before the coating of fat on the outside becomes scorched. They lose some water by evaporation and absorb considerable fat. The thinner the pieces the greater will be both these changes. Thus potato chips are found to contain only 2 per cent of water and 39.8 per cent of fat, whereas the raw tubers contain about 78 per cent water and 0.1 per cent fat.

When boiled potatoes are mashed with milk and butter, fried, or prepared in any of the multitudinous ways familiar to good cooks, their composition will be that of plain boiled potatoes plus the nutrients in the materials added. Purée of potatoes made with milk would make a much better single ration than plain potatoes, because it contains a higher proportion of protein. Salt, pepper, and other seasonings have also a decided value in that they improve the flavor of the potatoes and make them more appetizing. The potato may be prepared for the table in a great many ways, and this is an advantage, as it helps to give variety to the diet.

Grated potatoes are sometimes mixed with yeast and used in place of flour for making a kind of bread, rolls, or other similar food. Many cooks think that starting yeast for bread or rolls with potatoes instead of wheat flour makes a lighter sponge. This may be because the potatoes contain a more favorable proportion of the carbohydrates and other nutrients upon which the yeast feeds than does the wheat flour.

In this country the main test of the cooking quality of the potato is whether or not it yields a light, crystalline mass with almost distinct starch particles, or, in common parlance, its mealiness. Investigations were carried on at the Cornell Experiment Station to learn what it was that produced this mealiness, and the conclusion was reached that it depended mainly on the starch. If this was abundant and evenly distributed throughout the tuber the cells would burst open in cooking and make a light, flaky, uniform mass. If the starch was scanty in any part of the potato, water would be likely to settle there and make the cooked potato soggy. Mature but still fresh tubers hold more starch than either young or long stored ones as we have already seen, and the inner medullary layer is more likely to be poor in starch than the outer layer. Therefore the tubers most likely to cook into mealiness are the well-developed crisp ones. When the tubers are young or watery, or have a large core with many long arms branching into the outer medullary section, they are not so likely to be mealy when cooked.

This, however, does not tell the whole story. Anyone who cares for early spring potatoes knows that there is a quality between sogginess and mealiness which is very satisfactory and which is commonly described as waxiness. In many parts of Europe this condition is generally preferred and is considered a mark of excellence. While mealiness depends on starch and sogginess on water content, waxiness, according to the French authorities, Coudon and Boussard, depends on the proportion of protein to starch. If the protein is sufficiently abundant, it will as it hardens in cooking form a sort of waxy framework in which the starch will be lightly held together instead of separating into distinct flakes as in mealy potatoes, where there is not enough protein present to resist the pressure of the starch. Such waxy potatoes retain their shape better than the mealy ones and are more suitable for garnishing meats for salad making and for the preparation of many fancy dishes. As has been shown, the proportion of protein to starch is greater in young than in mature tubers, and therefore, in American potatoes at least, the early varieties are most likely to have this waxiness. In point of flavor there is almost as much difference as in consistency, as the nitrogenous tubers usually contain also a larger proportion of acids and perhaps sugars and solanin (see p. 19) than the starchy.

DRIED OR EVAPORATED POTATOES AND CANNED POTATOES.

Potatoes are so valuable in the diet that many attempts have been made to put them into a compact form in which they can be kept for a long time. This is usually accomplished by drying them, which both preserves them from decay and reduces their bulk. One of the oldest of such preparations is one long used in Peru and known as "chunno." To make it, part of the juice is pressed out of the potatoes, which are then dried in the air until they are reduced to about one-fourth of their original weight. There is a variety of similar preparations in American and European markets, and although the mode of procedure differs considerably in the various brands the main principle is the same, namely, to check bacterial action. The changes which we call decay are caused mainly by the development of bacteria. These can reproduce only where there is moisture and warmth present. Therefore, if the moisture is removed, their growth is retarded. The fact that the bulk of the potatoes is reduced at the same time is especially advantageous because such dried preparations are used mainly for camping expeditions, long sea voyages, and under other conditions where storage space is at a premium. The composition of such desiccated or evaporated potatoes is practically that of the original tubers minus more or less of the water. (See Table 1, p. 10.) Of course if extreme heat is used in the preparation, part of the starch may be changed to dextrin and there may be other minor changes in the chemical composition. There is no reason to suppose that these decrease the nutritive value. Various kinds of desiccated potatoes have been studied at the California Agricultural Experiment Station. Their water content ranged from 4.8 to 7.9 per cent, and their total carbohydrates from 77.9 to 80.6 per cent. In fact, their general composition was not unlike that of good white flour. They contained slightly less water, protein and fat, slightly more carbohydrates, and noticeably more mineral matters. Of course desiccated potatoes are supposed to be soaked in water before using and in this way regain somewhat their original characteristics. While their flavor and appearance can not equal those of good fresh potatoes, they are considered very appetizing and acceptable where fresh ones are unobtainable.

Chemical substances are sometimes used for improving the color (i. e., "bleaching") of desiccated potatoes. While a small quantity of these may be harmless, their continued presence in the diet might be very dangerous, and their use is not to be recommended.

Canned potatoes are on the market and are prepared for use in camps or wherever it is not convenient to cook food. They also may be kept in good condition for a long time. In composition such goods do not differ from similar freshly cooked potatoes.

STORAGE: ITS EFFECT ON QUALITY.

It is a fact of common experience that potatoes suffer more or less change during storage. If the tubers were originally diseased, the rot or other disease will go on developing until the potatoes are quite unfit for food, or if they have been bruised and are stored in a very warm, moist place, the injured portion offers an entrance to microorganisms and bacteria may develop in them and produce decay. But aside from these abnormal changes, there are others which occur under the best of conditions. Everyone knows how potatoes shrink and change their flavor as the winter grows late. The water tends to evaporate, and this is accompanied by certain chemical changes within the tuber. The potato, it must be remembered, is not a dead thing, but one in which active plant life is waiting to be renewed as soon as conditions are favorable. Even during the latent winter period the protoplasm of the cells is constantly producing minute changes in which part of the sugar is broken down and carbonic acid and water are given off. Part of the insoluble starch is also changed into dextrin and other soluble forms. This is believed to be due to the action of ferments normally present, which aid the plant by thus changing its stored food into a form in which the protoplasm can use it for new growth. The extent of these changes seems to depend on the age of the tuber and the temperature at which it is kept. The older it is the more ready it will be to begin its new growth and the more abundantly will the starch be converted into sugars. This explains why old potatoes are less starchy and mealy and sometimes sweeter than fresh ones. The temperature affects especially the activity of the protoplasm and the production of water and carbonic acid from the sugar, and thus it is that potatoes stored in a warm place are more likely to shrink than those in a cool place. These facts also suggest why frozen potatoes have such a sweet taste; the change of starch into sugar by the enzyms goes on regardless of the cold, but the activity of the cell protoplasm is checked by the cold and instead of being broken down the sugar accumulates. The sweet taste is more noticeable in tubers which have been slowly frozen than in those subjected to a sudden cold because the sugar has had a longer opportunity to form. If frozen potatoes are left for a few days in a moderate temperature, part of the sugar will revert to starch and the sweet taste in a measure disappear, but such potatoes never wholly regain their original flavor. Of course the amount of material which is broken down during storage will vary with the conditions, but sound potatoes properly stored should not shrink more than 10 or 12 per cent. The most favorable temperature for keeping potatoes is from 32 to 50° F., and if the storeroom is dry, well aired, and partly lighted, they are less likely to be attacked by disease or harmful bacteria.

Toward spring, or, if the tubers are old, even during the winter, potatoes begin to show signs of new growth, no matter how carefully they have been stored. Of course after the sprouting begins, the chemical changes take place very rapidly and the quality of the potatoes for food falls off decidedly. The reserve starch is drawn on by the growing shoots and with it goes the "mealiness."

POSSIBLE DANGERS FROM EATING POTATOES.

As has already been pointed out (p. 7), potatoes, when first introduced into Europe, were regarded as poisonous. This prejudice was soon overcome and the fact generally recognized that under ordinary circumstances potatoes are unquestionably wholesome food. Occasionally one hears of a person who is made ill by eating potatoes just as some are made ill by milk, by strawberries, or other food. Such cases are rare and due to individual idiosyncracy. Reference can not be made here to diabetes or other conditions of ill health in which potatoes and similar starchy foods are not permitted, since this is a subject which pertains to the practice of medicine rather than to a discussion of dietetics.

Cases of actual poisoning from potatoes are not unknown, and perhaps, without exception, have been found to be due to an abnormal solanin content such as is found in sprouted tubers, in very old potatoes, and in potatoes which have turned green on exposure to the light. Solanin is a characteristic constituent of potatoes and other plants of the same family. It is acrid in taste and is poisonous. Only a trace, however, about 0.01 per cent on an average, is found in the tubers of the varieties which are grown for the table, and this quantity is far too small to cause any unpleasant symptoms. It is claimed that the characteristic flavor of potatoes is due to this mere trace of solanin. At any rate, the very starchy potatoes which are lacking in flavor contain only about half as much solanin as the better table varieties. Potatoes which have grown on the surface of the ground or which have been exposed to the light frequently turn green, and such tubers contain abnormal amounts of solanin, as do old and shriveled potatoes which have sprouted. It is best not to use such old potatoes, but if they are eaten the flesh around the sprouts should be cut away, as this portion is particularly liable to contain solanin. Small or unripe tubers contain a higher percentage of solanin than full-grown tubers.

Analysis has shown that wild potatoes contain practically the same kind and proportion of nutrients as the cultivated varieties. The solanin content, however, is very considerably larger, 0.3 per cent having been found. These wild potatoes when cooked are slimy and almost translucent and entirely inedible.

MARKS OF GOOD POTATOES.

Appearance, taste, and consistency are the points by which we judge a cooked potato. Unfortunately it is not always easy to tell from their appearance which raw potatoes will prove the best, but there are certain marks which aid in making a choice.

The early varieties and young potatoes generally are preferable to more mature ones in point of flavor. Such tubers usually have a smoother skin than older ones. They are not as mealy, however, and do not keep as well. Late in the season, therefore, well developed tubers are safer. Very large ones are not especially desirable, partly because it is hard to cook them evenly and partly because they are often very variable in texture. Smooth, regularly shaped tubers with comparatively few eyes are more economical than irregular ones which can not be peeled without undue waste. In this country white or creamy-fleshed varieties are preferred, but in Europe yellow-fleshed varieties are most esteemed.

Different varieties may have distinct flavors, but the soil and climate in which they are grown and the fertilizers used cause such great variations that variety alone is no sure guide. Age is by far the most important point in determining flavor. The early varieties usually contain a larger proportion of mineral matters, acids, and protein, and therefore have a richer flavor, as has already been said. Tubers old enough to sprout begin to develop an acrid taste, due in part at least to an increased solanin content, which makes them less desirable. (See p. 19 also.)

Watery potatoes are always undesirable because they become soggy in cooking. Young tubers are more juicy than mature ones but their juice often holds so much more protein in solution that they cook with a pleasant waxy consistency. A good mealy potato should feel firm when pressed in the hand. If cut, it should separate crisply under the knife and be of even density throughout. If the core is large and soft, it will make a soggy mass full of holes in the center when cooked.

DIGESTIBILITY OF POTATOES.

In spite of the fact that potatoes are eaten by all sorts of people the world over and are generally conceded to be healthful as well as palatable, one occasionally hears it said that they are unwholesome. It has already been shown how little basis there is for the statement that they contain large quantities of cellulose and how much the danger of solanin poisoning is sometimes exaggerated. Better proof of their wholesomeness and digestibility than the facts of universal experience might seem superfluous. Still, much careful experimenting has been done to determine how much of each of the nutrients can be readily utilized by the body and the general effect of potatoes in the diet. Of course the real nutritive value of any material depends on the amount of nutrients which the digestive organs can make available for the formation of body material or the production of energy for its activities, rather than on the gross amount consumed. Almost the earliest digestion experiments with potatoes were made twenty-five or more years ago in Germany by Rubner, who experimented with a man accustomed to eating large quantities of potatoes, and kept him for two days on a diet of boiled potatoes, eaten either plain with salt or with oil and vinegar as a salad. As is common in such tests, he measured and analyzed the bodily excreta during the experiment, deducted the nutrients appearing in them from the amount consumed in the potatoes and let the difference between the two represent the amount available to the body. Such a diet is of course very irksome to a person accustomed to a more varied one, and it could hardly be expected that even with a subject used to large quantities of potatoes the digestive organs would do their work to the best advantage and it is not surprising to learn that there was some digestive disturbance. Nevertheless, 92.4 per cent of the carbohydrates and 67.8 per cent of the nitrogen were utilized by the body. In later experiments by Constantidini, the potatoes were made into a purée with milk and butter and in this more palatable diet 80.5 per cent of the total nitrogen was utilized and 99.5 per cent of the carbohydrates.

In Russia similar experiments were made, in which first a mixed diet and then potatoes alone were fed to healthy men. Here again 93 per cent of the carbohydrates were found to be digestible, but only 59 per cent of the protein. Later German experiments indicated a more thorough digestion of protein. Experiments have also been made under the auspices of this Department at the University of Minnesota. In these a mixed diet of eggs, milk, and cream, together with large quantities of potatoes, was given to a healthy young man for four days. The digestibility of the eggs, milk, and cream was already known and the digestibility of the potatoes alone was calculated by difference. Of the protein furnished by potatoes 71.9 per cent was utilized by the body and 93 per cent of the carbohydrates. A series of similar experiments with three men living on a mixed diet, including large quantities of potatoes and other vegetables, was made at Wesleyan University. In this series there was considerable variation in the digestibility of the protein by the three subjects, the results being, respectively, 93.5, 78.5, and 44.7 per cent. There was less variation in the digestibility of the carbohydrates, the figures being 99.9, 99.2, and 98 per cent. The average digestibility of protein in these experiments was 73 per cent, and of carbohydrates 99 per cent. The discrepancies between the results obtained by the different investigators are doubtless due to differences in method and to individual peculiarities of the subjects.

The experiments above described tell nothing of the ease or quickness of digestion. Little information is available on this point regarding any kind of food. In Beaumont's famous observations on a French-Canadian trapper with a gunshot wound in his stomach, roasted or baked potatoes were found to pass through the stomach into the intestines in about two hours, and boiled potatoes in three hours. Bread required three hours. The digestion of carbohydrates (the most important nutrients in potatoes) is accomplished mainly in the intestines, so that such data have very little practical value. To the ordinary healthy person it probably makes little difference whether within reasonable limits his food digests slowly or quickly, provided it digests normally.

There is practically no reliable evidence as to what form of cooking makes potatoes most digestible, but what little there is suggests that the differences between the various methods are slighter than is commonly supposed. It seems probable that well-cooked mealy potatoes in which the starch grains are thoroughly broken open offer less resistance to the action of the digestive juices than ill-cooked soggy ones with the flesh only partially broken down, which enter the alimentary tract in lumps. But how important such differences are no one really knows.

PLACE OF POTATOES IN THE DIET.

When potatoes are selling at 60 cents a bushel, 10 cents spent for them will buy about 10 pounds of tubers. The same sum spent for wheat bread at 5 cents a pound loaf will purchase only 2 pounds of material. At first glance it might seem that potatoes are much cheaper than bread, but they contain so much more refuse, and especially water, than the bread that the 10 pounds furnish only about the same quantities of protein and fat and slightly more carbohydrates than the 2 pounds of bread. Considering that hardly more than one-half of the protein of potatoes is of a kind suitable to build body tissue, it is easy to see why in spite of their cheapness and similar composition they should not occupy the same place in the diet as bread. A diet of bread alone would be rather too one-sided for the best development of bodily powers, but would come nearer to supplying the required protein without excess of carbohydrates than potatoes alone. According to generally accepted standards, a man at moderately active work requires about one-fourth pound of protein a day, along with sufficient fats and carbohydrates to give the total food an energy value of about 3,500 calories. It would take about 9 pounds of potatoes to furnish this energy, but that amount would yield only about 0.12 pound of true proteid, or one-half of the amount called for by the standard. About 19 pounds of potatoes would be needed to yield the required 0.25 pound of true proteid, an obviously impossible bulk for a day's ration. The "potato belly," often spoken of as occurring among the European peasants accustomed to eating large quantities of potatoes, represents the attempt of the body to adapt itself to such conditions by distending the stomach and bowels. Except under the stress of necessity, however, no one lives entirely on potatoes. Ordinarily they are eaten with other foods rich in protein, such as meat, milk, eggs, etc., and thus supplement these nitrogenous foods by furnishing the needed carbohydrates. Their abundant mineral matters are also valuable in aiding the processes of digestion, and are supposed to prevent scurvy. As was stated above, their carbohydrates are very thoroughly digested. They are easy to cook, and can be prepared in so many ways that they add variety to the list of vegetable dishes, especially in winter, when green vegetables are not common. They have a mild, agreeable flavor acceptable to almost everyone, but which is not sufficiently pronounced to become tiresome. Owing to the ease with which they are grown and their abundant yield, they sell at a price within the reach of all.

Considering all these advantages, it is not surprising that in the temperate regions of Europe and America they rank next to the breadstuffs as a source of carbohydrates in the diet.

CETEWAYO, OR ZULU, POTATOES.

The Cetewayo, or Zulu, potato, a wild variety of *Solanum tuberosum* found in Africa, is sometimes grown as a garden vegetable for its flavor and novelty. It has practically the same percentage composition as the ordinary potato. When cooked, the flesh is purple in color, but when brought in contact with vinegar, as in salads, it turns red.

SWEET POTATOES.

The plants which we know in the United States as sweet potatoes are known to the botanists as *Ipomœa batata* or *Batatas edulis* and are probably natives of the Malayan Archipelago. They were introduced into Europe earlier than the white potato and were formerly so commonly grown in the warmer countries of Europe that when the white potatoes supplanted them the latter took their English name from a corruption of the usual European name of sweet potatoes—batates. Since then, however, they have fallen into disfavor in Europe, being considered too sweet to be used as vegetables and not sweet enough to fill the place of cakes, sweet fruits, etc. The few that appear in European markets come mainly from southern Spain, northern Africa, or the Canary Islands, and are rather poor in quality.

There are many cultural varieties of the sweet potato, which differ in color, size, and other characteristics of the tuber.

The Chinese and Japanese use one or two varieties similar to those grown in the United States, and others are said to be grown in the Pacific islands, but the chief present home of the sweet potato is the warmer regions of North and Central America and the West Indies. In the Southern States they play almost as important a part as the white potatoes do in other parts of the country, and they have almost usurped the name potato. They are also sometimes called yams, a name which really belongs to an entirely different order of plants, hardly known outside of tropical countries (see page 32). "Yam," however, is not applied so much to the dry, starchy varieties which are demanded by Northern markets as to the sweeter and more juicy kinds preferred in the South. The edible portion of the sweet-potato plant is not an underground stem, like the white-potato tuber, but a true root. Its internal structure is more uniform than that of the white-potato tuber, but its rôle in the life history of the plant is much the same—i. e., to act as a storehouse of plant food for the growth and early development of a new crop of plants. Above ground the plant is a vine which occasionally produces flowers (and in warm countries, seeds) resembling somewhat their relatives, the morning-glory; ordinarily, however, it relies on its roots for reproduction. The first touch of frost is fatal to the vines of most varieties, so the cultivation is limited to warm climates where the growth is practically continuous and the plants perennials or to regions where the summer is long enough to insure the ripening of a crop. Some varieties are more resistant to cold than others and are extensively grown as far north as New Jersey.

The color of the sweet-potato skin ranges from light tan to dark brown or red and purplish tones, and the flesh from almost white or pale lemon yellow to a deep reddish orange. The medium and lighter shades are most frequently seen in the Northern markets. The weight of the tubers also varies considerably, but those which are of medium size and of regular shape are to be preferred for the table, as they cook more evenly and may be prepared with less waste.

COMPOSITION AND NUTRITIVE VALUE.

In general chemical composition the sweet-potato root resembles the tuber of the white potato, although there are important differences between them. The average composition of sweet potatoes raw and cooked is given in Table 2, together with similar figures for the white potato.

TABLE 2.—*Average composition of sweet and white potatoes.*

Kind of potato.	Refuse.	Water.	Protein.	Fat.	Carbohydrates.		Ash.	Fuel value per pound.
					Sugar, starch, etc.	Crude fiber.		
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Sweet potatoes (edible portion)		69.0	1.8	0.7	26.1	1.3	1.1	570
Sweet potatoes (as purchased)	20.0	55.2	1.4	.6	21.9		.9	460
Sweet potatoes (cooked)		51.9	3.0	2.1	42.1		.9	925
Sweet potatoes (canned)		55.2	1.9	.4	40.6	.8	1.1	820
White potatoes (edible portion)		78.3	2.2	.1	18.0	.4	1.0	375
White potatoes (as purchased)	20.0	62.6	1.8	.1	14.7		.8	310

The proportion of total sweet potato discarded with the skin as refuse is probably about the same as in white potatoes, and is estimated at 20 per cent. The most noticeable differences between white and sweet potatoes are in the carbohydrates and water. Sweet potatoes contain on an average about 9 per cent less water and 9 per cent more carbohydrates than white potatoes. They also contain as little, or even less, protein; but as the proportion of true proteids is higher than in white potatoes, being about 1.3 per cent, they supply rather more tissue-building material to the body, pound for pound. This advantage, however, is hardly large enough to be of consequence. Nor does the fact that they contain a trifle more fat or ether extract give them a higher value in the ordinary diet.

More important than any of these differences is that in the nature of the carbohydrates. Sweet potatoes contain a slightly larger proportion of crude fiber than white, though the amount is no higher than in most vegetables. As would be guessed from their flavor, they contain considerable quantities of sugar, part of which is cane sugar and part invert sugar or glucose. The proportion of sugar and starch varies with the climate. The warmer the place in which the plant is grown, the greater the proportion of food laid by in the form of sugar. Tropical sweet potatoes sometimes contain almost equal quantities of sugars and starch. Those grown in New Jersey, on the other hand, probably do not average more than 5 or 6 per cent of sugar, or about one-fifth of their total carbohydrates. As sweet potato culture has developed during recent years, certain varieties have been evolved which tend to store more starch even in the South, but climate has so much influence that probably the dry, starchy roots demanded by northern markets will never be produced south of North Carolina. On the other hand, the sweet, sirupy "yams," prized especially in the South, could hardly thrive, except in the South Atlantic and Gulf States or the extreme Southwest.

When sweet potatoes are first harvested they are left for some time to "sweat," or to lose part of their moisture by evaporation before they are shut up in storerooms. Where they are grown on a large scale they are sometimes "kiln-dried," i. e., placed in a temperature at about 90° F. for a week or more. Ordinarily, however, it is more convenient and quite as desirable to dry them more slowly at a lower temperature. After the "sweating period" they should be stored in a dry, well-ventilated place at a temperature of 50 to 60° F. Little is accurately known about the chemical changes which take place during storage. Almost everyone has learned from experience, however, that late in the season they become watery and sometimes disagreeable in taste, especially if they have been left in a cold place, the peculiar and characteristic flavor often noted being due to a bacterial disease, a sort of dry rot. These undesirable changes may take place at any temperature below 50° F. To avoid the danger of shipping in cold weather, the southern sweet potato crop is usually sent north early in the autumn and stored near the retail market. New Jersey sweet potatoes are often buried in sand for the winter and sold in excellent condition late in the season. Housekeepers should be careful not to keep sweet potatoes in cold, damp cellars; in fact, many consider it safer to buy them in small quantities as needed. In choosing sweet potatoes at the market, firm, fresh-looking ones should of course be preferred to the old and shriveled roots, and medium sized, smooth roots are more satisfactory than very large or very small ones.

Early in the season unripe potatoes are sometimes marketed, and may be recognized by cutting them, as the flesh will soon turn dark green, whereas the properly ripened roots will not change in color.

As is the case with storage, our knowledge of the changes which cooking makes in sweet potatoes is confined mainly to the facts of common experience. There is no reason to suppose, however, that these changes, particularly with reference to the rupturing of cell walls and the swelling of starch grains, due to the absorption of water, etc., differ greatly from those which take place in white potatoes. One point is generally noticeable—the longer the cooking is continued the more moist does the root become. This is probably due to changes in the carbohydrates. Part of the starch is doubtless changed to soluble carbohydrates by the heat and then dissolved in the juice, and the cane sugar is inverted—that is, split up into simpler sugar. The very sweet southern varieties become so moist during baking that a sirup frequently exudes through the skin.

Sweet potatoes may be prepared for the table in many of the ways used for other starchy vegetables, and are also used for many special dishes where their sweet flavor is an advantage. In some parts of Asia they are preserved in sugar much as we preserve fruits.

Directions for cooking potatoes and other vegetables will be found in an earlier bulletin of this series.[a]

DRIED AND CANNED SWEET POTATOES.

Dried sweet potatoes were formerly a domestic product, and strings of them were hung from the rafters along with apples and other dried fruits and vegetables, but in these days of storage warehouses the custom has very largely passed away. Special devices for evaporating sweet potatoes are on the market, and desiccated sweet potatoes are prepared in much the same way as desiccated white potatoes and are sold to some extent. The South Carolina Experiment Station has devoted considerable attention to studying the possibilities of this industry.[b]

Within recent years the practice of canning sweet potatoes has been developed with so much success that it is now an important industry. Medium sized roots are usually chosen for canning, and they are generally put up in 3-pound tins. Canned sweet potatoes have been used in the army ration in the Philippines and are said to be in demand in lumber camps and mining camps. They are also used like other canned vegetables when it is not convenient to depend upon a fresh supply.

Although the bulk of the sweet potato crop is used for human food, some of the coarser kinds are fed to stock and a small part is used for the preparation of sweet potato flour—that is, sliced, dried, and ground tubers—and for the manufacture of starch.

DIGESTIBILITY AND PLACE IN THE DIET.

So far as can be learned, the only digestion experiments which have been made with sweet potatoes are those reported from Japan and quoted at length in a summary of Japanese investigations published by this Department.[c] Judging by these results, 98 per cent of the carbohydrates of sweet potatoes are digested, or about the same as in the case of white potatoes. The values for protein were very variable, but on the whole were lower than for protein of white potatoes.

It is a matter of common experience that sweet potatoes are wholesome and as a rule are digested by the average man without distress. Many persons find the starchy varieties so "dry" that they do not relish them without adding large quantities of butter. This makes a rather rich mixture and is perhaps accountable for the digestive disturbance occasionally experienced.

---

[a] U. S. Dept. Agr., Farmers' Bul. 256.

[b] South Carolina Sta. Bul. 71; U. S. Dept. Agr., Farmers' Bul. 169, p. 25.

[c] U. S. Dept. Agr., Office of Experiment Stations Bul. 159, p. 174.

Considering both composition and digestibility, it may be said that the nutritive value of sweet potatoes is much the same as that of white potatoes and that they are well fitted to occupy the same place in the diet and furnish a palatable substitute for white potatoes. Further, their characteristic and pleasing flavor is an additional advantage. In the North they frequently cost somewhat more than white potatoes, but are still among the cheaper vegetables. In the South they are quite as cheap or cheaper than white potatoes, and merit their extensive use.

THE JERUSALEM ARTICHOKE.

The Jerusalem artichoke (Jerusalem being a corruption of "girasole," the Italian name for sunflower) is a tuber-bearing member of the sunflower family, as its Latin name, *Helianthus tuberosus*, implies, and is entirely distinct from the French or globe artichoke. Many farmers in this country are prejudiced against the Jerusalem artichoke, considering it an undesirable weed, but in Europe, and to a certain extent in the United States, it is believed to be a valuable plant, since the forage may be fed to stock, while the abundant tubers are useful as a vegetable and also for farm animals. In flavor the tubers slightly resemble the globe artichoke, and this doubtless accounts for their name. They contain on an average 78.7 per cent water, 2.5 per cent protein, 0.2 per cent fat, 17.5 per cent total carbohydrates of which 0.8 per cent is crude fiber, and 1.1 per cent ash. In the absence of accurate determinations it may be assumed that the waste in preparing the tubers for the table is the same as in the case of potatoes, namely, 20 per cent. Judged by these values the artichoke tubers are quite similar in composition to potatoes (see page 10). They differ, however, very markedly in respect to the nature of the carbohydrates which are present, inulin and levulin (which are closely related to starch chemically), and a considerable amount of pectose bodies replacing the starch which is characteristic of potatoes. It is owing to the [illegible] Jerusalem artichokes are included in the vege[illegible] suffering with diabetes. Little is known [illegible] carbohydrates which these [illegible] that they do not differ [illegible] common experience has [illegible] wholesome and a pleasant addi[illegible] injured by frost and may [illegible] vegetables are not very com[illegible] easily grown, the Jerusalem [illegible]

STACHYS.

This vegetable, known to the botanists as *Stachys sieboldi*, has been introduced into America from Japan and has a number of different names, such as Japanese potato, Chinese artichoke, chorogi, etc., but the name stachys seems to have been adopted as the common one in this country. The plant is a small perennial belonging to the mint family and produces just below the ground a multitude of small white crisp edible tubers varying from an inch to two and one-half inches in length and about one-half an inch in thickness and marked by irregular spiral rings, which give them a corkscrew-like appearance.

Stachys has been tested at the New York (Cornell) and a number of the other agricultural experiment stations, and proved so easy of cultivation and pleasant in taste (the flavor resembling artichokes) that the vegetable has made many friends and is now procurable at the markets in most of our larger cities. The agreeable quality is in considerable measure due to the crispness of the tubers, and as this disappears when they are exposed to the air they should be stored in sand or sawdust. They are ready for use when the plant dies down in the autumn, though they may be easily carried over the winter and are prepared for the table like potatoes or other vegetables, or may be eaten raw like radishes. On an average, stachys has the following percentage composition: 78.6 per cent water, 2.7 per cent protein, 0.1 per cent fat, 17.4 per cent total carbohydrates (0.7 per cent being crude fiber), and 1.2 per cent ash. Like the other roots and tubers which have been spoken of, the stachys is characterized by a high water content, and carbohydrates constitute the principal nutritive material. According to some authorities inulin is present in stachys in place of starch, while others state that starch is replaced by a special carbohydrate called stachyose. A digestion experiment with stachys was made some years ago in Japan[a] and it was found that the carbohydrates were about as thoroughly digested as those of potatoes, 95 per cent being retained by the body.

TROPICAL STARCH-BEARING ROOTS.

In the Tropics a very large proportion of the carbohydrates of the diet of both native and European residents is furnished by starch-bearing roots, such as the cassava, yam, yautia, and taro. None of these are common vegetables in the United States, though some or all are sold in the oriental quarters of our cities and sometimes in a limited way in other markets, and the cassava and yautia are grown to some extent in the Southern States. In Porto Rico and our other island dependencies such starch-bearing roots are very important articles of diet, and as they may be readily shipped in good condition and are known to be palatable and wholesome it seems not unlikely that they may become important additions to the list of starchy vegetables commonly used in the United States.

---

[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 159, p. 171.

The percentage composition of sweet cassava and some cassava products, taro, yams, and yautias is given in the following table, together with that of potatoes, for purposes of comparison:

TABLE 3.—*Average composition of some tropical starch-bearing roots.*

Kind of food.	Water.	Protein.	Fat.	Total carbohydrates.		Ash.	Fuel value per pound.
				Sugar, starch, etc.	Crude fiber.		
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Sweet cassava	66.0	1.1	0.2	30.2	1.8	0.7	610
Cassava starch	10.5	.5	.1	88.8		.1	1,625
Cassava bread	10.5	9.1	.3	79.0		1.1	1,650
Cassava cakes or wafers	10.3	1.1	.2	85.2	1.6	1.6	1,670
Taro	70.9	1.8	.2	23.2	.8	1.2	475
Yams	72.9	1.8	.2	23.8	.6	.9	475
Yautia tubers	70.0	2.2	.2	26.1	.6	.9	585
Potatoes	78.3	2.2	.1	18.0	.4	1.0	375

CASSAVA.

The cassava now being cultivated to a considerable extent in Florida, but rather as a cheap source of commercial starch, glucose, etc., than as a direct foodstuff, is an American plant widely used for food purposes throughout Central America, the West Indies, and the hot regions of South America. There appear to be two principal varieties, the sweet cassava and the bitter cassava, but only the sweet (*Manihot aipi*) is cultivated in the United States. The bitter cassava gets its name from the fact that the raw root contains considerable amounts of a poisonous prussic acid compound, which is volatile and may be removed by cooking, or even, it is said, by exposure to the hot sun. Both varieties are eaten as vegetables, boiled, baked, fried, or cooked in other ways, and by drying and grinding are made into a flour which forms the basis of various sorts of bread and biscuits. Round, thin, crisp cassava cakes are not infrequently on sale in the United States under a variety of trade names and are popular. Cassava starch is made in large quantities in the Tropics and has always been prized as a palatable and valuable food starch.

Judged by the figures given in Table 3, the cassava is as rich in starch as the potato, and like it can be classed as a succulent carbohydrate food. The amount of protein and fat present is very small, while the amount of mineral matter or ash is practically the same as in very many other common foods. The culture and uses of cassava and other related matters have been discussed in a previous publication[a] of this series.

---

[a] U. S. Dept. Agr., Farmers' Bul. 167.

TARO.

The taro (known botanically as *Caladium colocasia* or *Colocasia antiquorum*), which is so commonly grown for its edible roots in the Tropics, is more familiar to most persons in the United States in one of its garden forms, namely the large-leafed ornamental plant sometimes called "elephants' ears." There are many varieties of this plant, and it constitutes one of the most important starch-yielding foods of native races in southern China, India, the West Indies, etc. It has a rather disagreeable, acrid taste when raw, but this disappears on cooking. The root may be eaten boiled, baked, or cooked in other ways, and a sort of flour is also made from it. The native Hawaiians eat it in the form of poi—a sticky dough-like dish which is allowed to ferment before it is used.

The composition of taro has been studied in connection with the nutrition investigations of this Office at the University of California.[a] As the figures quoted in Table 3 show, it does not differ very materially from potatoes in composition. Judged by a digestion experiment made in Japan,[b] the carbohydrates of taro compare favorably in digestibility with those of other starchy roots, 95 per cent having been assimilated.

YAUTIA.

The yautia, which is closely related to the taro botanically, though it belongs to a different group known as Xanthosoma, is a very important starchy food in the West Indies, where it is known by a variety of names, such as taniers or tannias, cocoes, eddoes, taye, etc. The cultivated varieties do not produce seed, though they occasionally put out abortive blossoms. The plants will thrive in almost any moist region free from frost and produce a large crop of roots in return for comparatively little cultivation. In Porto Rico every small farmer has his plat of yautias, and next to sweet potatoes and yams they are the most important native food crop. The flesh of the different varieties ranges in color from white to deep orange red. Both root stalks and the tubers which grow from them are edible, though the tubers are considered the more tender and of better flavor.

The culture and uses of the yautia and related questions have been discussed in full in a recent bulletin[c] of the Porto Rico Experiment Station.

The thin skin is usually removed before the yautias are cooked, and this entails on an average a loss of about 5 per cent of the total weight of the tubers. Yautias are cooked as a vegetable in many ways like potatoes, and a starch is sometimes made from them which is used for making puddings, cakes, etc. In connection with the nutrition investigations carried on by the Office of Experiment Stations, a number of tests were made of the culinary qualities of yautias, taro, and yams supplied by the Porto Rico Experiment Station, and it was found that these vegetables could be readily prepared for the table like potatoes in a number of appetizing ways.

---

[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 68.

[b] U. S. Dept. Agr., Office of Experiment Stations Bul. 159, p. 171.

[c] Porto Rico Sta. Bul. 6.

YAMS.

The true yams (Diascorea), which are often confused with sweet potatoes (see p. 24), belong to a group of climbing plants. The number of varieties found throughout the Tropics and subtropics is very large and many of them bear edible starch-yielding roots which vary greatly in size, some being no larger than potatoes and others several feet in length and weighing 30 pounds or more. The true yams are grown extensively in southern China, Oceania, Porto Rico, the West Indies and other tropical regions and are very important sources of carbohydrates in the diet, ranking in Porto Rico, for instance, next to the sweet potato.

When used as a vegetable they are boiled, roasted, or cooked in other ways like the potato, or may be made into a sort of flour and used as a breadstuff. The flours and starches prepared from the yams and other tropical roots of course differ from wheat flour in that they contain no true gluten. The flesh of many of the commoner yams is white, though certain varieties are yellow fleshed and very much like a sweet potato in appearance. In flavor the yam very closely resembles the white potato, and, as may be seen by the figures for average composition in Table 3, also resemble the potato in composition. In the cooking tests already referred to above, some of the yams used were of the large white varieties, weighing several pounds. These were cut in convenient slices, cooked like potatoes, and could hardly be distinguished from them in flavor or appearance. The Japanese investigations noted elsewhere (p. 27) include a study of the digestibility of yams, and 96 per cent of the total carbohydrates was found to be assimilated.

SUCCULENT ROOTS, TUBERS, AND BULBS.

There are a number of common root vegetables which resemble each other in so many points that they may be conveniently grouped together for discussion. Prominent among these are beets, carrots, turnips, parsnips, etc. In many cases the leaves and stems are also used as pot herbs or "greens," especially while they are young and tender. Most of these vegetables have developed from wild forms whose roots are small, tough, and possessed of stronger flavor and odor than the cultivated varieties. Since earliest times the ordinary succulent roots have been common garden crops. They are cheaply grown in almost any temperate region and are very generally used as food.

There are also a number of these roots grown for the table in Europe and elsewhere which are not often seen in the United States but which agree in general character with those referred to above. Parsnip-chervil, Spanish salsify, and Teltow turnips may be cited as examples. Among the succulent roots used by the Chinese and other Orientals, but not commonly used by western races, may be mentioned arrowhead, sacred lotus, and water chestnut. These were included in a study[a] of Chinese foods sold in this country, which was made at the California Experiment Station in cooperation with the nutrition investigations of the Offices of Experiment Stations.

Of the bulbs used as food in the United States, various members of the onion family are the only ones which need special mention, though lily bulbs of different sorts are eaten by the Chinese and may be purchased in our large cities, and various wild bulbs have always been gathered as food by the Indians.[b]

The following table shows the composition of the succulent roots, tubers, and bulbs commonly used as food, as well as the composition of potatoes, which is included for purposes of comparison.

TABLE 4.—*Average composition of succulent roots, tubers, and bulbs.*

Kind of vegetable.	Refuse.	Edible portion.						
		Water.	Protein.	Fat.	Carbohydrates.		Ash.	Fuel value per pound.
					Sugar, starch, etc.	Crude fiber.		
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Beets, fresh	7.0	87.5	1.6	0.1	8.8	0.9	1.1	215
Beets, cooked		88.6	2.3	.1	7.4		1.6	185
Celeriac	20.0	84.1	1.5	.4	11.8	1.4	.8	285
Carrots, fresh	20.0	88.2	1.1	.4	8.2	1.1	1.0	210
Carrots, desiccated		3.5	7.7	.6	80.3		4.9	1,790
Parsnips	20.0	83.0	1.6	.5	11.0	2.5	1.4	300
Salsify "Oyster plant"	25.0	85.4	4.3	.3	6.8	2.0	1.2	250
Black salsify	20.0	80.4	1.0	.5	17.1	2.3	1.0	390
Radishes		91.8	1.3	.1	5.1	.7	.1	135
Turnips, white	10.0	89.6	1.3	.2	6.8	1.3	.8	160
Turnips, yellow (ruta-bagas)	10.0	88.9	1.3	.2	7.3	1.2	1.1	185
Kohl-rabi	20.0	91.1	2.0	.1	4.2	1.3	1.3	145
Onions	30.0	87.6	1.6	.3	9.1	.8	.6	225
Garlic		64.7	6.8	.1	27.9	.8	1.5	650
Potatoes	20.0	78.3	2.2	.1	18.0	.4	1.0	375

As a rule the succulent roots, tubers, and bulbs contain larger quantities of water than the starchy vegetables described in the preceding sections and consequently have a lower nutritive value. The proportion of protein which they contain is low, and of this small amount not more than a third, and frequently only a fifth, is in the form of albumin or similar compounds. Various sugars, pectose bodies, and, in some cases, pentosans, very generally constitute the reserve material which the plants store up instead of the starch characteristic of such roots as the potato and sweet potato. As a class these vegetables are characterized by very marked flavors and odors due to the small amount of volatile oils and similar substances which they contain.

---

[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 68.

[b] U. S. Dept. Agr., Div. Botany, Contrib. U. S. Nat. Herbarium, vol. 7, No. 3.

Succulent roots, tubers, and bulbs, when considered from the standpoint of the protein, fat, and carbohydrates which they supply, are much less important components of the diet than concentrated cereal foods or even the comparatively succulent starchy roots and tubers. They do, however, furnish some nutritive material, and are appetizing and generally relished, and their use often makes palatable an otherwise comparatively flavorless dish or meal. Furthermore, they contribute bulk to the diet, and this is an important consideration from the standpoint of normal digestion. Perhaps one of the most important functions of these succulent roots, etc., as indeed of most of our common vegetables and fruits, is to supply the body with mineral salts which are needed for the building and repair of tissue, for the proper carrying out of physiological functions, and particularly to insure the alkalinity of the blood.

The ways in which these and other vegetables may be prepared for the table are very numerous and have been discussed in an earlier bulletin of this series.[a]

The various vegetables included in the above table each have some special characteristics which merit discussion and so they will be taken up separately.

BEETS.

Although the greater part of the total crop of beets or beet root, as they are called in Great Britain, is used for the production of sugar or for the feeding of farm animals, yet beets are used in such large quantities as a human food that they rank as one of the most common table vegetables. White or yellow table beets are occasionally to be seen, but the red ones are the most common. The flavor is more delicate in the summer varieties than in the later maturing sorts. Each year the southern-grown beets are becoming more common in our winter market and are superseding the large fully matured roots which were formerly so often stored as winter vegetables and which late in the season often develop a rather bitter and unpleasant flavor. It is sometimes said that beets are more nutritious than turnips, carrots, etc., but a comparison of the values for average composition given in Table 4 does not substantiate this statement, all these vegetables being very much alike as regards the proportion of nutritive material present.

---

[a] U. S. Dept. Agr., Farmers' Bul., 256.

Cane sugar constitutes a considerable portion of the total carbohydrates of beets, as high as 10 per cent or more having been often reported. Some reducing sugar is also present. In beets grown for sugar making the percentage of cane sugar is considerably higher, sometimes 20 per cent or more, though such high values are the exception. Beets are sometimes said to be very rich in cellulose, but this does not seem to be the case with American varieties whose average composition has been quoted. When beets are cooked the water becomes highly colored, and it is undoubtedly true that a considerable part of the sugar and other soluble nutrients which they contain is extracted, but how much material is removed can not be stated as no cooking experiments with beets have been found on record.

Three digestion experiments were made several years ago at Wesleyan University in which it was found that 72 per cent of the protein, 97 per cent of the carbohydrates, and 90 per cent of the total energy value of the beets were utilized by the body, figures which compare very favorably with those obtained with potatoes in tests made with the same subjects.

Beets are frequently canned at home for winter use and the commercial canned article is a very well-known product. As regards composition, the canned goods have practically the same chemical composition as freshly cooked beets.

CELERIAC.

This vegetable, which is also known as turnip-rooted celery, or knot celery, is closely related to our ordinary celery, being indeed a cultural variety of the same original plant grown under conditions which have developed the root rather than the stalk. In Europe it is by far the most common form of celery, but has never been extensively cultivated in the United States, though it is found in the larger markets. The roots are white and more or less globular in shape, closely resembling turnips in appearance. As the figures in Table 4 show, they have much the same composition as the other succulent roots and tubers. Celeriac has a pronounced celery flavor due apparently to a complex oil like that in the seed, which is rather stronger than that of the tender celery stalks, but when cooked celeriac does not differ very greatly in taste from ordinary stewed celery.

A German investigator has reported mannit, a starch like carbohydrate, and also small amounts of asparagin, a constituent of asparagus, in tuberous-rooted celery. So far as can be learned no digestion experiments have been made with this vegetable, but it would doubtless differ little in digestibility from beets or other succulent roots.

It is often said that celery is a nerve food, but there seems to be no warrant for such a statement, and the belief is probably a survival of the time when specific virtues were attributed to almost all plants and vegetables.

CARROTS.

Carrots are grown in many varieties, and vary greatly in color, size, flavor, and other characteristics, those most commonly raised for the table being of medium size, deep yellow color, tender, and of delicate flavor. Young carrots are much more satisfactory than old ones, as when fully matured they tend to become hard and woody, especially at the core, while not infrequently the flavor of old carrots is disagreeably strong. Some varieties are more satisfactory than others for winter use, but the winter carrots are, generally speaking, more used for seasoning soups and other dishes than as a table vegetable. Improved methods of transportation, storage, etc., have, moreover, made the small tender southern-grown carrot comparatively common as a winter vegetable.

In composition carrots do not differ very materially from other similar roots, carbohydrates constituting the principal nutritive material. Sugar is an important constituent, 12 per cent or more being sometimes present, though perhaps 5 or 6 per cent would more nearly represent the average. Small amounts of pentosans have also been reported. The proportion of sugar in the carrot, beet, and other vegetables is very variable, being influenced by size, maturity, method of storage, and other factors. Carrots owe their color to the presence of a yellow organic compound known as "carrotin," which is sometimes extracted with the juice and used for coloring butter.

The water in which carrots have been boiled is quite yellow and has a sweet taste, plainly showing that some of the nutrients have been removed in the process of cooking. In order to determine the amount of this loss, experiments were made with carrots at the University of Minnesota, similar to those made with potatoes referred to on page 14. The carrots were cleaned and cut into pieces of various sizes and then boiled in different ways. Whether the water was hot or cold at the start made less difference than in the case of potatoes, but it was found that the more water used, the greater were the losses. On the other hand, the more rapidly the carrots were boiled, the smaller was the loss. Small pieces, doubtless because a relatively large surface was exposed to the action of the boiling water, lost about 30 per cent of their total nutrients, 20 per cent of the true proteids, and 26 per cent of sugar, while large pieces lost only 20 per cent, 5 and 16 per cent, respectively. Figure 4 represents in graphic form the composition of the carrot and the loss of nutrients when boiled.

A European investigator[a] found that when carrots were steamed they became soft a little more quickly than when cooked in hot water and lost considerably less material, as the water over which they were steamed contained only 0.69 per cent of the total material as compared with 3.75 per cent in the case of the water in which they were boiled. The material extracted from the carrots in cooking consisted principally of sugar or similar carbohydrate.

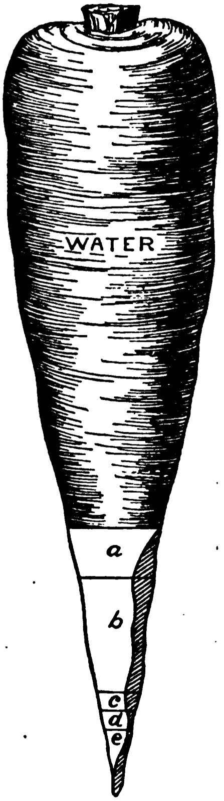


FIG. 4.—The composition of the carrot and the loss of nutrients when boiled: *a*, fiber, starch, fat, etc.; *b*, sugar; *c*, nonproteid nitrogenous matter; *d*, proteid nitrogenous matter; *e*, mineral matter. The hatched portion represents the loss when medium-sized pieces were boiled.

A number of years ago a German investigator studied the digestibility of carrots, and found that about 60 per cent of the protein and 80 per cent of the carbohydrates were retained in the body. His results were too meager to justify general deductions, and it seems probable that the vegetable would, generally speaking, be as digestible as beets or potatoes. Carrots are commonly considered to be wholesome and a valuable addition to the diet, both as a seasoning vegetable and cooked in a variety of ways.

Dried or desiccated carrots are on the market and are recommended for use wherever small bulk and good keeping qualities are important considerations. These goods resemble the fresh carrots in composition, except that they have been concentrated by the evaporation of water.

PARSNIPS.

Parsnips belong to the same botanical order as carrots and resemble them in form and general habit of growth. The flesh of the root, however, is paler, being white or light cream color, and the flavor is quite distinct and very pronounced. Parsnips may be kept in the ground over winter and are especially welcome additions to the diet in early spring, when vegetables which have been stored are losing their good qualities. For some reason boiled parsnips were long considered in some regions of Europe to be the proper vegetable to serve with salt fish, but this tradition is not followed in the United States, and they are cooked and served in a variety of ways, as are the other vegetables which they closely resemble.

As regards composition, parsnips are much like the other roots and tubers, but contain rather higher quantities of cellulose, particularly in the core, which becomes stringy and woody when the roots are old. How much of the total nutritive material is lost in boiling is not definitely known, but it is commonly thought to be considerable. The amount is doubtless affected by the same conditions as were noted with carrots. So far as can be learned no digestion experiments have been made with parsnips.

---

[a] Landw. Jahrb. Schweiz., 19 (1905), p. 619.

SALSIFY.

The name "salsify" is commonly applied to three distinct vegetables, namely the common white salsify known as "oyster plant" or "vegetable oyster" (*Tragopogon porrifolius*), black salsify (*Scorzonera hispanica*), the schwarz wurzel of the Germans, and the so-called Spanish salsify (*Scolymus hispanicus*). The first of these is very commonly grown in the United States, and black salsify is also grown though less extensively, while Spanish salsify is seldom cultivated. Both common salsify and black salsify closely resemble the other succulent roots used as food in general character. They are not injured by mild frosts and may remain in the ground until late winter or early spring. As the popular name of salsify implies, the flavor suggests that of oysters.

The principal carbohydrate stored in black salsify is inulin rather than starch, and so this vegetable is often used in the diet of diabetics. The proportion of materials lost in cooking and the digestibility have not been made the subject of investigations so far as can be learned, but there is every reason to suppose that salsify would resemble the other succulent roots in these respects.

RADISHES.

The radishes most commonly grown in the United States are those with red exterior and white flesh, although white and dark purple varieties are also well known. Though formerly red radishes were a typical spring vegetable they are now so commonly grown under glass that they are available all winter in large markets. To be at their best, radishes should be eaten before the roots are fully mature and should be very fresh. Besides losing their crispness they become sweeter in taste if they are kept long after they are gathered, owing to the action of a ferment or enzym normally present which changes part of the radish starch to sugar. Similar enzyms are found in beets, carrots, etc., but in these vegetables their action is less marked.

As will be seen from the figures in Table 4, the young radishes analyzed contained even more water than the turnips. The characteristic pungent flavor is due to organic compounds similar to the essential oil of mustard. Radishes are almost always eaten raw, and are so succulent and tender that they are doubtless rather thoroughly assimilated, though so far as can be learned their digestibility has not been studied. It is frequently said that they are productive of digestive disturbances. Whether this is attributable to the crude fiber which they contain or to the bodies which give the high flavor or to both together it is not possible to say, but such digestive disturbances are by no means general, and when they occur may be due to the fact that succulent foods are frequently swallowed without sufficient mastication.

TURNIPS.

A great variety of turnips is grown throughout temperate climates, some of which being course in texture are used as food for farm animals while other varieties are raised as table vegetables. There is considerable variation in the color, flavor, and composition of the turnip, the yellow-fleshed sorts as a group being commonly distinguished from the white by the name "Swedes" or "ruta-bagas." In the summer the early white varieties are usually preferred in spite of the fact that they are more watery, while in winter the yellow turnips are more commonly used. Solid as the turnip roots appear they contain on an average about 89 per cent of water or a trifle more than is found in whole milk. Only about 20 per cent of the total protein present is in the form of albumin. Carbohydrates are the principal nutritive material, glucose, cane sugar, pectose or jelly-yielding bodies, pentosans, and crude fiber being the characteristic carbohydrates present. The flavor of turnips is due to compounds of sulphur, which are so volatile that when turnips are fed to cows they pass through the body tissues and into the milk and give it an unmistakable flavor of turnips. In cooking, these pungent substances are broken down to some extent and pass off into the air. So far as can be learned no accurate data are available regarding the digestibility of turnips, but they are commonly conceded to be wholesome, palatable, and useful additions to the diet, and there is no reason to suppose that they are not well assimilated.

KOHL-RABI.

Kohl-rabi, or turnip cabbage, represents a curious variety of the turnip and cabbage families in which the reserve material of the plant is stored in a tuber-like enlargement of the stem just above the surface of the soil rather than beneath. Although, strictly speaking, it does not belong to the roots and tubers, it is so similar to them that it has been included in this discussion. Kohl-rabi is considered best in the early summer, when it is still young and tender, but it is commonly found on the market until late fall. In flavor it is more delicate than either turnips or cabbage, though it resembles them more nearly in this respect than it does other common vegetables.

ONIONS, GARLIC, ETC.

The various members of the onion family are so commonly used for flavoring purposes that they should perhaps be included with the flavoring vegetables. Such classifications as those followed in this bulletin are, however, of course, purely arbitrary, and in the case of the onion family some varieties are so largely used as vegetables that it has seemed best to discuss them in connection with the roots, tubers, etc., as they are used in practically the same way in the diet. All the members of the onion family are characterized by very strong flavor and odor due to the presence of characteristic oil-like organic compounds of sulphur, which vary somewhat in flavor and composition with different varieties of the plant and are usually more abundant in the bulbs or roots than in the leaves or other parts. They are very volatile and are broken down by heat to some extent and consequently the cooked vegetable has a much milder flavor than the raw.

The common onion in its many varieties is the best known and most used in the United States of the onion family. The total crop produced is very large, and quantities are also imported from southern Europe, Bermuda, and the West Indies. As with most vegetables, the young and somewhat immature onions are preferred to the fully matured bulbs, though the latter have the best keeping qualities. White varieties are milder in flavor than the red or yellow sorts and are generally preferred as table vegetables. If they are to be kept through the winter, onions should be taken from the ground as soon as the stalks begin to wither and cured or dried in the air for about ten days. If the moisture is not thus removed before they are stored they will not keep well.

The proportion of water and nutrients in onions varies greatly, not only with the variety but with the stage of growth and the method of storing them. Roughly speaking, the chemical composition is very similar to that of the succulent roots also included in Table 4. They contain, however, rather larger quantities of cellulose, particularly in the outer layers, which are usually removed before cooking. The waste in preparing onions for the table may be as high as 50 per cent, but 20 or 30 per cent is perhaps a fairer average. The onions are succulent and tender, and there is every reason to suppose that they are as thoroughly digested as other similar vegetables, though so far as can be learned this question has not been made the subject of definite investigation. They are commonly conceded to be wholesome and have been prized since earliest times as a valuable addition to the diet. The characteristic sulphur bodies which they contain are believed to stimulate the flow of digestive juices, and these and other constituents have a desirable effect in overcoming a tendency to constipation. As onions contain no appreciable amount of starch and little sugar they are usually allowed to invalids from whose diet starchy foods are excluded.

Garlic is a member of the onion tribe, which forms a group of small bulbs called "cloves" in the place of one large bulb, as with the more common varieties of the onion. It is used almost exclusively as a flavoring plant, though some of the mild sorts grown in the Mediterranean region are eaten as a vegetable. In this country it is little eaten save by some of the foreign population, and this is perhaps unfortunate, as rightly used it undoubtedly adds much to the palatability of salads, meats, and other dishes.

Shallot, cibol, etc., are varieties of the onion family much esteemed for their flavor in Europe though they are not common in the United States. Leeks and chives, two other sorts, develop almost no bulbs and are grown for their leaves, leeks being used as a green vegetable or pot herb and chives as a salad plant or for seasoning. Although most families in the United States are familiar with onions only, many good cooks consider that the other members of the group are also indispensible for seasoning purposes.

ROOTS USED AS CONDIMENTS.

Several roots have pronounced aromatic qualities which give them a value quite independent of the nutritive material which they contain. In addition to increasing the flavor of food it seems possible that such condiments may stimulate the flow of digestive juices as well as please the palate. Horse-radish and ginger are the most common condimental roots, though chicory, which is commonly considered in Europe a palatable addition to coffee, may also be mentioned, as well as licorice root and calamus or sweet flag.

Horse-radish is a moisture-loving plant of the mustard family which is cultivated throughout north temperate countries and is very frequently found wild in the United States, as it long ago escaped from cultivation. The root is long, slender, and has a sharp, peppery flavor, owing to the presence of an essential oil which much resembles in general character that in the radish and other members of the mustard family. As regards composition, horse-radish contains on an average 86.4 per cent water, 1.4 per cent protein, 0.2 per cent fat, 10.5 per cent total carbohydrates, and 1.5 per cent ash, and has a fuel value of 225 calories per pound. The root contains a large proportion of water. Starch constitutes the principal carbohydrate present, and, as might be expected from the stringy character of the roots, the percentage of crude fiber is rather high. Though varieties of horse-radish are sometimes cooked as a vegetable, and it is used for seasoning meat, sauces, etc., it is perhaps most commonly used in this country mixed with vinegar as a condiment. It is popularly supposed that the vinegar softens the crude fiber to some extent and makes it more digestible.

Ginger, the underground root stock of *Zingiber officinale*, is perhaps most commonly used dry as a spice, though the fresh root or green ginger is common in autumn, being used in pickle making, preserving, and in other ways. The young and tender ends of the branching root or rhizome, called ginger buds, are the most delicate portion as regards both texture and flavor. Large quantities of ginger root are preserved in rich sugar sirup, the round stone jars of "Canton ginger" being an old-fashioned confection which is still much prized. The crystallized or candied ginger is even more common and is frequently served as a sweetmeat, and is also used in making deserts of various sorts. While the nutritive value of preserved and crystallized ginger depends, of course, quite largely on the added sugar, the fresh root contains some nutritive material, the average composition being 85.6 per cent water, 1.0 per cent protein, 0.6 per cent fat, 11.4 per cent sugar, starch, etc., 1.0 per cent crude fiber, and 1.4 per cent ash, and has a fuel value of 240 calories per pound. Of the total fat or ether extract, about half consists of the ethereal oil, which together with a pungent nonvolatile constituent "gingerol," gives to ginger its characteristic flavor.

SUMMARY.

The plants which store their reserve material in underground roots, tubers, and bulbs have in many instances come to be regarded by man as among the most important foodstuffs. Cultivation has to a great extent modified the size, structure, flavor, and appearance of the plant parts which are eaten, and the garden varieties are as a rule superior to the wild in these respects and show important modifications in the season of growth and in other ways. As a class the edible roots, tubers, and bulbs may be divided into the following groups: (1) Starch-yielding vegetables, as potatoes and sweet potatoes; (2) succulent roots, as beets, carrots, and parsnips; and (3) condimental or flavoring roots, as horse-radish and ginger. Such plants as garlic and onions might be included in the last group, but are here considered with the succulent roots as some of the milder flavored varieties are eaten in such quantities that they may be fairly considered as foods rather than simply as flavoring vegetables.

As a class the edible roots, tubers, and bulbs have a high-water content and are valued as additions to the diet for their appetizing, succulent qualities and the bulk which they give as well as for the nutritive material which they supply. Starch is the material most commonly stored in these underground receptacles of nutritive material, though it is not infrequently replaced in some plants by inulin, a closely related body, by sugars of different sorts, pectoses, and other carbohydrates. The proportion of nitrogenous material in such foodstuffs is small, and true albumin seldom constitutes more than a third of the total protein. The proportion of fat or ether extract is also small, being composed in some cases very largely of wax-like bodies found in the skin, or of coloring matter; and in other cases, of volatile oils and similar substances which give the plants their characteristic flavor and odor. The mineral matter or ash is an important constituent of these vegetable foods, the proportion though small being about the same as is found in many other common articles of the diet. Sodium, potassium, and iron salts, and sulphur and phosphorus compounds, etc., are the common ash constituents. As the mineral matters exist in combination with organic acids and other bodies they contribute materially to the flavor of the tubers, roots, etc.

In tropical regions yams, cassava, and other starch-bearing roots seldom seen in northern markets are among the most important vegetables and are cooked and served in a variety of ways. Starch is frequently made from these roots, and they are also used in the production of a sort of meal or flour eaten in large quantities. In temperate and northern regions the potato is the leading starch-yielding vegetable.

The potato varies considerably in composition with age, variety, and conditions of growth. The ripened tubers are usually richer in starch and have better keeping qualities than the immature tubers, but the latter contain larger proportions of mineral matters, acids, etc., and are consequently of richer flavor. Cooking breaks down the cellulose walls of the potato cells which inclose the starch grains, gelatinizes or hydrates the starch so that it becomes softer and looser in structure, and improves the flavor largely by volatilizing acid bodies and similar constituents or otherwise modifying their character. In young tubers, which usually contain a larger proportion of protein to starch than the mature ones, the heat of cooking causes the protein to coagulate or harden around the starch, producing a "waxy" rather than a "mealy" mass. When potatoes are peeled before cooking, some nutritive material is usually removed with the inedible skin, the total material removed (designated refuse in food analyses) being on an average 20 per cent. When potatoes are cooked some water is usually lost by evaporation, and the loss of nutritive material may, under certain circumstances, be also quite considerable. Thus, when potatoes were peeled and soaked before boiling the loss of food material has been found to be, in round numbers, as much as 7 per cent of the total dry matter. Much smaller quantities are lost if the potatoes are not soaked, and when they are baked or boiled in their jackets the loss of nutritive material is insignificant. During storage potatoes lose water by evaporation, and this loss may be so great that the tubers become shriveled. Some of the starch which is present is changed to sugar, especially if the tubers are frozen or if they begin to sprout. Minute quantities of a poisonous substance of very pronounced flavor, solanin, are found in potatoes, and to this constituent they very largely owe their characteristic flavor. In old or sprouted potatoes the amount of solanin may be great enough to cause illness. When such tubers are used for the table, the flesh around the sprouts should always be carefully cut away, as this is more likely to contain solanin than any other portion. Under ordinary conditions the chance of any injurious effects from solanin in potatoes is very remote, and they are generally conceded to be among the most wholesome and useful starch-yielding foods, particularly when it is remembered that digestion experiments have shown that the starch and other nutritive material which they supply are very well assimilated by the body. Although they contain too small a proportion of the tissue-building proteid in proportion to their carbohydrates to provide a satisfactory ration if used alone, they are admirably fitted for combination with milk, meat, eggs, and other proteid foods to form a palatable well-balanced diet.

Sweet potatoes are common starch-yielding vegetables throughout the United States, and the proportion eaten in the Southern States, where the bulk of the crop is produced, is much greater than in other localities. Much of the reserve carbohydrates these tubers contain is in the form of sugar. In the South varieties so rich in sugar that they become sirupy in cooking are considered superior, but in the northern markets the starchy sweet potatoes are preferred. Some varieties of sweet potatoes are frequently called yams, but this name properly belongs to a distinct order of tropical plants which yield edible tubers, some of them of very large size and others closely resembling sweet potatoes in form and appearance, though they lack the characteristic sweet flavor.

Beets, carrots, parsnips, salsify, turnips, and onions are the most common of the so-called succulent root crops used as food. They differ from the starch-yielding vegetables like potatoes mainly in containing a larger proportion of water, 85 to 90 per cent on an average, and consequently a smaller proportion of nutritive material. Furthermore, it is generally true that starch is not the characteristic carbohydrate of these vegetables, its place being taken by sugars of different sorts, pectose bodies, and other similar carbohydrates, while the percentage of crude fiber is also rather higher than in the edible starch-yielding roots and tubers. Many of the vegetables included in this group are characterized by marked flavors and odors due to the presence of volatile organic sulphur compounds in their juices. In the members of the onion tribe these are especially strong, and some varieties are used almost exclusively as flavoring materials, while other and milder sorts are also used in large quantities as table vegetables.

Though not very nutritious in proportion to their bulk, root crops as a class offer some advantages over most other vegetable foods. They are so easily grown and are so productive that under ordinary conditions they sell at prices within the reach of all. Many of them may be kept over winter in such good condition that they are never out of season. The carbohydrates, the principal nutritive mateiral present, are in forms which are readily and well assimilated. The characteristic flavor which some of these vegetables possess is a decided advantage, as it makes the vegetables palatable and adds to the variety of the diet. Succulent vegetables of all sorts contribute bulk to the diet, and so are valuable from the standpoint of hygiene, as within limits bulkiness is a favorable condition for normal digestion and also of importance in overcoming a tendency to constipation. In addition, the mineral salts which they contain serve an important purpose in helping to maintain the alkalinity of the blood and have other physiological uses.

○

FARMERS' BULLETINS.

The following is a list of the Farmers' Bulletins available for distribution, show the number, title, and size in pages of each. Copies will be sent free to any add in the United States on application to a Senator, Representative, or Delegate in C gress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted h been discontinued, being superseded by later bulletins.

22. The Feeding of Farm Animals. Pp. 40.
24. Hog Cholera and Swine Plague. Pp. 16.
25. Peanuts: Culture and Uses. Pp. 24.
27. Flax for Seed and Fiber. Pp. 16.
28. Weeds and How to Kill Them. Pp. 20.
29. Souring and Other Changes in Milk. Pp. 22.
30. Grape Diseases on the Pacific Coast. Pp. 15.
32. Silos and Silage. Pp. 30.
33. Peach Growing for Market. Pp. 24.
34. Meats: Composition and Cooking. Pp. 31.
35. Potato Culture. Pp. 24.
36. Cotton Seed and Its Products. Pp. 16.
39. Onion Culture. Pp. 30.
41. Fowls: Care and Feeding. Pp. 24.
42. Facts About Milk. Pp. 32.
44. Commercial Fertilizers. Pp. 88.
46. Irrigation in Humid Climates. Pp. 27.
47. Insects Affecting the Cotton Plant. Pp. 32.
48. The Manuring of Cotton. Pp. 16.
49. Sheep Feeding. Pp. 24.
51. Standard Varieties of Chickens. Pp. 48.
52. The Sugar Beet. Pp. 48.
54. Some Common Birds. Pp. 48.
55. The Dairy Herd. Pp. 30.
56. Experiment Station Work—I. Pp. 30.
58. The Soy Bean as a Forage Crop. Pp. 24.
59. Bee Keeping. Pp. 48.
60. Methods of Curing Tobacco. Pp. 24.
61. Asparagus Culture. Pp. 40.
62. Marketing Farm Produce. Pp. 31.
63. Care of Milk on the Farm. Pp. 40.
64. Ducks and Geese. Pp. 55.
65. Experiment Station Work—II. Pp. 32.
66. Meadows and Pastures. Pp. 30.
68. The Black Rot of the Cabbage. Pp. 22.
69. Experiment Station Work—III. Pp. 32.
70. Insect Enemies of the Grape. Pp. 23.
71. Essentials in Beef Production. Pp. 24.
72. Cattle Ranges of the Southwest. Pp. 32.
73. Experiment Station Work—IV. Pp. 32.
74. Milk as Food. Pp. 39.
77. The Liming of Soils. Pp. 24.
78. Experiment Station Work—V. Pp. 32.
79. Experiment Station Work—VI. Pp. 27.
80. The Peach Twig-borer. Pp. 16.
81. Corn Culture in the South. Pp. 24.
82. The Culture of Tobacco. Pp. 22.
83. Tobacco Soils. Pp. 23.
84. Experiment Station Work—VII. Pp. 32.
85. Fish as Food. Pp. 32.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
91. Potato Diseases and Treatment. Pp. 15.
92. Experiment Station Work—IX. Pp. 30.
93. Sugar as Food. Pp. 31.
95. Good Roads for Farmers. Pp. 46.
96. Raising Sheep for Mutton. Pp. 48.
97. Experiment Station Work—X. Pp. 32.
98. Suggestions to Southern Farmers. Pp. 48.
99. Insect Enemies of Shade Trees. Pp. 30.
100. Hog Raising in the South. Pp. 40.
101. Millets. Pp. 30.
102. Southern Forage Plants. Pp. 48.
103. Experiment Station Work—XI. Pp. 30.
104. Notes on Frost. Pp. 24.
105. Experiment Station Work—XII. Pp. 32.
106. Breeds of Dairy Cattle. Pp. 48.
107. Experiment Station Work—XIII. Pp. 32.
108. Saltbushes. Pp. 20.
109. Farmers' Reading Courses. Pp. 20.
110. Rice Culture in the United States. Pp. 28.
111. Farmer's Interest in Good Seed. Pp. 24.
112. Bread and Bread Making. Pp. 40.
113. The Apple and How to Grow It. Pp. 32.
114. Experiment Station Work—XIV. Pp. 28.
115. Hop Culture in California. Pp. 28.
116. Irrigation in Fruit Growing. Pp. 48.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 30
120. Insects Affecting Tobacco. Pp. 32.
121. Beans, Peas, and other Legumes as F Pp. 38.
122. Experiment Station Work—XVI. Pp. 3
124. Experiment Station Work—XVII. Pp. 3
125. Protection of Food Products from Inju Temperatures. Pp. 24.
126. Practical Suggestions for Farm Buildi Pp. 48.
127. Important Insecticides. Pp. 46.
128. Eggs and Their Uses as Food. Pp. 40.
129. Sweet Potatoes. Pp. 40.
131. Household Tests for Detection of Oleo garine and Renovated Butter. Pp. 10.
132. Insect Enemies of Growing Wheat. Pp.
133. Experiment Station Work—XVIII. Pp.
134. Tree Planting in Rural School Grounds. 32.
135. Sorghum Sirup Manufacture. Pp. 40.
136. Earth Roads. Pp. 24.
137. The Angora Goat. Pp. 48.
138. Irrigation in Field and Garden. Pp. 40.
139. Emmer: A Grain for the Semiarid Regi Pp. 16.
140. Pineapple Growing. Pp. 48.
141. Poultry Raising on the Farm. Pp. 16.
142. Principles of Nutrition and Nutritive V of Food. Pp. 48.
143. Conformation of Beef and Dairy Ca Pp. 44.
144. Experiment Station Work—XIX. Pp. 3
145. Carbon Bisulphid as an Insecticide. P
146. Insecticides and Fungicides. Pp. 16.
147. Winter Forage Crops for the South. P
149. Experiment Station Work—XX. Pp. 32
150. Clearing New Land. Pp. 24.
151. Dairying in the South. Pp. 48.
152. Scabies in Cattle. Pp. 32.
153. Orchard Enemies in the Pacific North Pp. 39.
154. The Home Fruit Garden: Preparation Care. Pp. 16.
155. How Insects Affect Health in Rural Dist Pp. 19.
156. The Home Vineyard. Pp. 22.
157. The Propagation of Plants. Pp. 24.
158. How to Build Small Irrigation Ditches. 28.
159. Scab in Sheep. Pp. 48.
161. Practical Suggestions for Fruit Gro Pp. 30.
162. Experiment Station Work—XXI. Pp. 3
164. Rape as a Forage Crop. Pp. 16.
165. Silkworm Culture. Pp. 32.
166. Cheese Making on the Farm. Pp. 16.
167. Cassava. Pp. 32.
168. Pearl Millet. Pp. 16.
169. Experiment Station Work—XXII. Pp.
170. Principles of Horse Feeding. Pp. 44.
172. Scale Insects and Mites on Citrus T Pp. 43.
173. Primer of Forestry. Pp. 48.
174. Broom Corn. Pp 30.
175. Home Manufacture and Use of Unferme Grape Juice. Pp. 16.
176. Cranberry Culture. Pp. 20.
177. Squab Raising. Pp. 32.
178. Insects Injurious in Cranberry Culture. 32.
179. Horseshoeing. Pp. 30.
181. Pruning. Pp. 39.
182. Poultry as Food. Pp. 40.

183. Meat on the Farm: Butchering, Curing, and Keeping. Pp. 37.
184. Marketing Live Stock. Pp. 40.
185. Beautifying the Home Grounds. Pp. 24.
186. Experiment Station Work—XXIII. Pp. 32.
187. Drainage of Farm Lands. Pp. 38.
188. Weeds Used in Medicine. Pp. 45.
190. Experiment Station Work—XXIV. Pp. 32.
192. Barnyard Manure. Pp. 32.
193. Experiment Station Work—XXV. Pp. 32.
194. Alfalfa Seed. Pp. 14.
195. Annual Flowering Plants. Pp. 48.
196. Usefulness of the American Toad. Pp. 16.
197. Importation of Game Birds and Eggs for Propagation. Pp. 30.
198. Strawberries. Pp. 24.
199. Corn Growing. Pp. 32.
200. Turkeys. Pp. 40.
201. Cream Separator on Western Farms. Pp. 23.
202. Experiment Station Work—XXVI. Pp. 32.
203. Canned Fruits, Preserves, and Jellies. Pp. 32.
204. The Cultivation of Mushrooms. Pp. 24.
205. Pig Management. Pp. 40.
206. Milk Fever and Its Treatment. Pp. 16.
208. Varieties of Fruits Recommended for Planting. Pp. 48.
209. Controlling the Boll Weevil in Cotton Seed and at Ginneries. Pp. 32.
210. Experiment Station Work—XXVII. Pp. 32.
211. The Use of Paris Green in Controlling the Cotton Boll Weevil. Pp. 23.
213. Raspberries. Pp. 38.
215. Alfalfa Growing. Pp. 40.
216. The Control of the Boll Weevil. Pp. 32.
217. Essential Steps in Securing an Early Crop of Cotton. Pp. 16.
218. The School Garden. Pp. 40.
219. Lessons from the Grain Rust Epidemic of 1904. Pp. 24.
220. Tomatoes. Pp. 32.
221. Fungous Diseases of the Cranberry. Pp. 16.
222. Experiment Station Work—XXVIII. Pp. 32.
223. Miscellaneous Cotton Insects in Texas. Pp. 24.
224. Canadian Field Peas. Pp. 16.
225. Experiment Station Work—XXIX. Pp. 32.
226. Relation of Coyotes to Stock Raising in the West. Pp. 24.
227. Experiment Station Work—XXX. Pp. 32.
228. Forest Planting and Farm Management. Pp. 22.
229. The Production of Good Seed Corn. Pp. 24.
231. Spraying for Cucumber and Melon Diseases. Pp. 24.
232. Okra: Its Culture and Uses. Pp. 16.
233. Experiment Station Work—XXXI. Pp. 32.
234. The Guinea Fowl. Pp. 24.
235. Preparation of Cement Concrete. Pp. 32.
236. Incubation and Incubators. Pp. 32.
237. Experiment Station Work—XXXII. Pp. 32.
238. Citrus Fruit Growing in the Gulf States. Pp. 48.
239. The Corrosion of Fence Wire. Pp. 32.
240. Inoculation of Legumes. Pp. 8.
241. Butter Making on the Farm. Pp. 32.
242. An Example of Model Farming. Pp. 16.
243. Fungicides and their Use in Preventing Diseases of Fruits. Pp. 32.
244. Experiment Station Work—XXXIII. Pp. 32.
245. Renovation of Worn-out Soils. Pp. 16.
246. Saccharine Sorghums for Forage. Pp. 37.
247. The Control of the Codling Moth and Apple Scab. Pp. 21.
248. The Lawn. Pp. 20.
249. Cereal Breakfast Foods. Pp. 36.
250. The Prevention of Wheat Smut and Loose Smut of Oats. Pp. 16.
251. Experiment Station Work—XXXIV. Pp. 32.
252. Maple Sugar and Sirup. Pp. 36.
253. The Germination of Seed Corn. Pp. 16.
254. Cucumbers. Pp. 30.
255. The Home Vegetable Garden. Pp. 47.
256. Preparation of Vegetables for the Table. Pp. 48.
257. Soil Fertility. Pp. 39.
258. Texas or Tick Fever and Its Prevention. Pp. 45.
259. Experiment Station Work—XXXV. Pp. 32.
260. Seed of Red Clover and Its Impurities. Pp. 24.
261. The Cattle Tick. Pp. 22.
262. Experiment Station Work—XXXVI. Pp. 32.
263. Practical Information for Beginners in Irrigation. Pp. 40.
264. The Brown-tail Moth and How to Control It. Pp. 22.
265. Game Laws for 1906. Pp. 54.
266. Management of Soils to Conserve Moisture. Pp. 30.
267. Experiment Station Work—XXXVII. Pp. 32.
268. Industrial Alcohol: Sources and Manufacture. Pp. 45.
269. Industrial Alcohol: Uses and Statitiscs. Pp. 29.
270. Modern Conveniences for the Farm Home. Pp. 48.
271. Forage Crop Practices in Western Oregon and Western Washington. Pp. 39.
272. A Successful Hog and Seed-Corn Farm. Pp. 16.
273. Experiment Station Work—XXXVIII. Pp. 32.
274. Flax Culture. Pp. 36.
275. The Gipsy Moth and How to Control It. Pp. 22.
276. Experiment Station Work—XXXIX. Pp. 32.
277. The Use of Alcohol and Gasoline in Farm Engines. Pp. 40.
278. Leguminous Crops for Green Manuring. Pp. 27.
279. A Method of Eradicating Johnson Grass. Pp. 16.
280. A Profitable Tenant Dairy Farm. Pp. 16.
281. Experiment Station Work—XL. Pp. 32.
282. Celery. Pp. 36.
283. Spraying for Apple Diseases and the Codling Moth in the Ozarks. Pp. 42.
284. Insect and Fungous Enemies of the Grape East of the Rocky Mountains. Pp. 48.
285. The Advantage of Planting Heavy Cotton Seed. Pp. 16.
286. Comparative Value of Whole Cotton Seed and Cotton-Seed Meal in Fertilizing Cotton. Pp. 14.
287. Poultry Management. (In press.)
288. Nonsaccharine Sorghums. Pp. 28.
289. Beans. Pp. 28.

O

1008 Issued June 19, 1907.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 296.

Experiment Station Work,

XLI.

Compiled from the Publications of the Agricultural Experiment Stations.

WELLS AND PURE WATER.
PHOSPHATES AND SOIL ACIDITY.
PURE SEED v. POOR SEED.
DISEASE-RESISTANT CLOVER.
ERADICATION OF WILD MUSTARD.
STERILIZATION OF SOILS FOR PREVENTING PLANT DISEASES.
SEEDLESS TOMATOES.
PICKLING OLIVES AND MOCK OLIVES.
HAY BOX OR FIRELESS COOKER.
INSECT ENEMIES OF SHADE TREES.
FEEDING WHOLE GRAIN.
IMPROVEMENT OF CATTLE.
VENTILATION OF STABLES.
HOG COTS.
PRESERVING EGGS.
AMERICAN CAMEMBERT CHEESE.

MAY, 1907.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.
A. C. TRUE, Director.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

THE AGRICULTURAL EXPERIMENT STATIONS.

Alabama—
College Station: *Auburn;* J. F. Duggar.[a]
Canebrake Station: *Uniontown;* J. M. Richeson.[b]
Tuskegee Station: *Tuskegee;* G. W. Carver.[a]
Alaska—*Sitka:* C. C. Georgeson.[c]
Arizona—*Tucson:* R. H. Forbes.[a]
Arkansas—*Fayetteville:* W. G. Vincenheller.[a]
California—*Berkeley:* E. J. Wickson.[d]
Colorado—*Fort Collins:* L. G. Carpenter.[a]
Connecticut—
State Station: *New Haven;* E. H. Jenkins.[a]
Storrs Station: *Storrs;* L. A. Clinton.[a]
Delaware—*Newark:* Harry Hayward.[a]
Florida—*Gainesville:* P. H. Rolfs.[a]
Georgia—*Experiment:* Martin V. Calvin.[a]
Hawaii—
Federal Station: *Honolulu;* J. G. Smith.[c]
Sugar Planters' Station: *Honolulu;* C. F. Eckart.[a]
Idaho—*Moscow:* H. T. French.[a]
Illinois—*Urbana:* E. Davenport.[a]
Indiana—*Lafayette:* A. Goss.[a]
Iowa—*Ames:* C. F. Curtiss.[a]
Kansas—*Manhattan:* C. W. Burkett.[a]
Kentucky—*Lexington:* M. A. Scovell.[a]
Louisiana—
State Station: *Baton Rouge.*
Sugar Station: *Audubon Park, New Orleans.*
North Louisiana Station: *Calhoun;* W. R. Dodson (*Baton Rouge*).[a]
Maine—*Orono:* C. D. Woods.[a]
Maryland—*College Park:* H. J. Patterson.[a]
Massachusetts—*Amherst:* W.P.Brooks.[a]
Michigan—Agricultural College: C. D. Smith.[a]
Minnesota—*St. Anthony Park, St. Paul:* W. M. Liggett.[a]
Mississippi—*Agricultural College:* W. L. Hutchinson.[a]
Missouri—
College Station: *Columbia;* H. J. Waters.[a]
Fruit Station: *Mountain Grove;* P. Evans.[a]
Montana—*Bozeman:* F. B. Linfield.[a]
Nebraska—*Lincoln:* E. A. Burnett.[a]
Nevada—*Reno:* J. E. Stubbs.[a]
New Hampshire—*Durham:* W. D. Gibbs.[a]
New Jersey—*New Brunswick:* E. B. Voorhees.[a]
New Mexico—*Agricultural College:* L. Foster.[a]
New York—
State Station: *Geneva;* W. H. Jordan.[a]
Cornell Station: *Ithaca;* L. H.Bailey.[a]
North Carolina—*Raleigh:* B. W. Kilgore.[a]
North Dakota—*Agricultural College:* J. H. Worst.[a]
Ohio—*Wooster:* C. E. Thorne.[a]
Oklahoma—*Stillwater:* W. L. English.[a]
Oregon—*Corvallis:* J. Withycombe.[a]
Pennsylvania—*State College:* H. P. Armsby.[a]
Porto Rico—*Mayaguez:* D. W. May.[c]
Rhode Island—*Kingston:* H. J. Wheeler.[a]
South Carolina—*Clemson College:* J. N. Harper.[a]
South Dakota—*Brookings:* J. W. Wilson.[a]
Tennessee—*Knoxville:* H. A. Morgan.[a]
Texas—*College Station:* J. W. Carson.[d]
Utah—*Logan:* P. A. Yoder.[a]
Vermont—*Burlington:* J. L. Hills.[a]
Virginia—*Blacksburg:* A. M. Soule.[a]
Washington—*Pullman:* E. A. Bryan.[a]
West Virginia—*Morgantown:* J. H. Stewart.[a]
Wisconsin—*Madison:* W. A. Henry.[a]
Wyoming—*Laramie:* B. C. Buffum.[a]

---

[a] Director. [b] Assistant director. [c] Special agent in charge. [d] Acting director.

EXPERIMENT STATION WORK.

Edited by W. H. BEAL and the Staff of the Experiment Station Record.

Experiment Station Work is a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. TRUE, Director, Office of Experiment Stations.

CONTENTS OF NO. XLI.

	Page.
Wells and a pure water supply	5
Availability of phosphates in relation to soil acidity	6
Pure seed versus poor seed	7
Selection for disease-resistant clover	9
Eradication of wild mustard	10
Sterilization of soils for the prevention of diseases of plants	11
Production of seedless tomatoes	13
Pickling olives and mock olives for home use	14
The hay box or fireless cooker	16
Combating insect enemies of shade trees	19
Feeding whole grain	21
The improvement of cattle	23
Ventilation of stables	25
Hog cots	27
Preserving eggs in water glass	29
American Camembert cheese	31

EXPERIMENT STATION WORK.[a]

WELLS AND A PURE WATER SUPPLY.[b]

In a discussion of the disposal of dairy and farm sewage in such a way that the water supply may not be injured, O. Erf, of the Kansas Experiment Station, draws some general deductions regarding the construction and care of wells which are of much interest.

It must be borne in mind that the well on a dairy farm and, indeed, on any farm or in any dooryard, can not receive too much care, for it supplies the water for household use, for the dairy farm, for cheese factories, and for other purposes which are related to food supply. Well water is most commonly contaminated in two ways, either by surface water, which runs directly into the well, or by barnyard drainage, household slops, and cesspools.

Sewage disposal may be so managed that it is not a menace to the water supply, one of the most satisfactory methods employing a septic tank, and, as the Kansas experiments show, this need not involve any great trouble or expense.

Discussing well construction, the Kansas bulletin states that—

> Nearly all of the bacterial life exists in the upper strata of the soil. Soil 10 or 12 feet below the surface of the earth is perfectly sterile, unless it has within it a crevice or opening so that surface sewage can run down. Therefore due care should be taken in digging and constructing a well so that direct contamination will be prevented.
>
> The well itself must be so constructed that the impurities can not get into it from above or from the sides. Water should be filtered through 10 or 12 feet of fine soil. To prevent the surface pollution a water-tight wall should be built in a well down below the water level. This can be built of hard, burned brick and cemented on the outside. Clay should be pounded around this.
>
> Where drilled wells are used the lining of the well should be an iron tube driven into the bore and the outside should be flushed with thin cement. The well should be properly covered and the surrounding ground should be considerably higher than the general level of the soil. The walls should extend at least 3 feet above the surface of the ground and a ground fill made so that it will slope from the wall. The top of the fill should be covered with at least 12 inches of clay or loam, upon which it is advisable to have some sod or a layer of sand or, best of all, a pavement sloping in all directions.

If due precautions are taken in the disposal of sewage, care of waste and garbage, and in the proper construction of wells, there is little danger of well water becoming polluted. An abundant supply of pure water[a] is a great step toward insuring the health of the household dependent upon the well, and increasing the wholesomeness and healthfulness of the butter, milk, cream, and other products sold from the farm.

---

[a] A progress record of experimental inquiries, published without assumption of responsibility by the Department for the correctness of the facts and conclusions reported by the stations.

[b] Compiled from Kansas Sta. Bul. 143.

AVAILABILITY OF PHOSPHATES IN RELATION TO SOIL ACIDITY.[b]

In an article on this subject in the last report of the Wisconsin Experiment Station A. R. Whitson and C. W. Stoddart call attention to the fact that the fertilizer tests made by the agricultural experiment stations throughout the country have agreed in showing that soil acidity is almost always accompanied by a need of phosphatic fertilizer. They tested the fertilizer requirements of a large number of Wisconsin soils both in the field and in the plant house and the results confirm "the conclusion that acid soils need phosphates, and it will be possible, by a careful test of a soil with litmus paper, to tell if it needs, or will need in the immediate future, a phosphate fertilizer. * * *"

The litmus-paper test can be made in the field, if the soil is moist enough, by inserting a broad bladed knife into the ground and opening a slit wide enough to insert a rather long, narrow strip of litmus paper. With the knife blade the soil is pressed closely against the litmus paper and at the end of about three minutes the paper is carefully removed from the soil. If the paper shows red spots, the soil is acid. If the soil in the field is not moist enough for this test a small portion of it may be placed in a porcelain dish, moistened to the right consistency with distilled water and worked up with a knife blade. By pressing a piece of litmus paper between two portions of the soil with the knife blade and leaving it three minutes, acidity or nonacidity will be shown by the presence or absence of red spots. In every case, whether in the field or in the laboratory, care should be taken that the hands touch the soil as little as possible, because perspiration will turn blue litmus paper red, and lead to erroneous conclusions. The knife blade, the distilled water, and the porcelain dish should be tested to see that they are free from acid. * * *

The reason for this need of phosphates in acid soils may possibly be found in the fact that acids dissolve phosphate minerals, and soil acids, whether due to decomposition of organic matter in the case of peat or to long cultivation in the case of upland soils, will undoubtedly have a decided solvent action on phosphates in the soil, particularly on the calcium phosphates. When once in solution these phosphates are readily washed out by heavy rains. There is undoubtedly considerable phosphate material still remaining in acid soils, but it is at least unavailable to the plant, and it is possible that it may be a phosphate of iron or aluminum, such as dufrenite or wavellite, insoluble in weak acids. * * *

Soils not acid probably contain considerable calcium and magnesium carbonates which, going into solution as the bicarbonates in water charged with carbon dioxid, serve to retain the phosphorus in the form of tricalcium phosphate, relatively insoluble in the soil moisture and yet soluble enough to supply the needs of the growing crop.

---

[a] For an earlier paper on pure water see U. S. Dept. Agr., Farmers' Bul. 73, p. 3.

[b] Compiled from Wisconsin Sta. Rpt. 1906, p. 171.

PURE SEED VERSUS POOR SEED.[a]

The Kansas Station recently published a special circular comparing the cost of obtaining a full stand of alfalfa when pure and poor seed are used. Attention is called to the fact that in 1905 Kansas had an area of 1,018,206 acres devoted to cultivated forage crops, of which 602,560 acres was in alfalfa. The cost of seeding this alfalfa acreage at the rate of 15 pounds per acre with seed at 16 cents per pound, every single seed being good, would amount to $1,446,128, but taking as a basis from among the number of alfalfa seed samples analyzed by the station 28 showing an average of total impurities of 46.1 per cent and an average number of seed true to name but incapable of germinating of 34.5 per cent, it would have cost $1,935,042 to secure a full stand on the same area.

Letters from all portions of the State indicate that poor alfalfa seed is quite common. The principal impurities are dead and defective alfalfa seed itself, trefoil, English plantain or buckhorn, dodder, Russian thistle, crab grass, foxtail, and other weed seeds, and the adulterants often found are trefoil, bur clover, and sweet clover. It is pointed out that with good standard alfalfa seed, averaging 83 per cent of the seed true to name and capable of germinating, the cost of seeding an acre would be $2.40. This represents the actual cost of the 83 per cent of good seed, the 17 per cent being waste, and the real cost per bushel of viable seed is therefore about $12 instead of $10, at which the seed and the waste together was originally bought. In a certain sample of seed analyzed by the station only 20.2 per cent of the seeds were true to name and capable of germinating. A computation based on the cost of the standard seed shows that in order to obtain from the use of this poor seed as much of a stand as could have been secured with 15 pounds of the standard seed 73.9 pounds of this seed would have been necessary, and the actual cost of seeding an acre would have been brought up to $11.92, and the actual cost of the seed exclusive of the 79.8 per cent of waste to $49.26 per bushel. In addition to this prohibitive cost, the use of seed like this sample would have deposited on each acre over 4,000,000 weed seeds of various species, or 105 on each square foot. The use of seed represented by another sample studied would have raised the cost to $5.75 per acre, and would have sown this area with approximately 167,000 weeds of various sorts, including 95,000 plantain seed, 19,000 dodder seed, and 25,000 foxtail seed. Bad seed gives a weak, poor stand of alfalfa and a dense growth of weeds and wild grasses. In the 28 samples referred to above the impurities ranged from 21.6 to 100 per cent, the trash or dirt from

---

[a] Compiled from Kansas Sta. Spec. Circ., January 30, 1907.

0.3 to 31.9 per cent, and the number of kinds of foreign seed present from 3 to 34.

These investigations with reference to bluegrass seed within the State show that Kentucky bluegrass seed is extensively adulterated with Canadian bluegrass seed, from which it is not distinguishable by the ordinary observer, especially when mixed with it. English bluegrass is very commonly adulterated with cheat, the seeds of the two plants resembling each other sufficiently to make adulteration easily possible. The quality of English bluegrass seed is frequently very poor, the germination in many cases not being above 40 per cent. A certain lot of this seed bought and sold in the fall of 1905 contained less than 50 per cent of germinable seeds, and the percentage of weed seeds was so high that on each acre there were sown with the English bluegrass seed 142,230 seeds of crab grass, 111,000 seeds of dock, 393,670 smartweed seeds, 62,340 cheat seeds, together with 111,000 miscellaneous seeds, making a grand total of 820,240 weed seeds of all kinds. The crop harvested contained only about 15 per cent of English bluegrass seed, while 79 per cent was cheat and the rest seeds of such weeds as bindweed, dock, foxtail, and pigweed.

The brome grass seed marketed in the State is also adulterated with cheat, and much of it has a percentage of germination of only about 40. A comparison of the different grades of seed as estimated and determined by the station is given in the following table:

The cost per acre of standard and poor seeds compared.

Samples.	Good seeds.	Seed required per acre.	Cost of seeding an acre.	Germinable seed, cost per bushel.	Weed seeds per acre.	Weeds per square foot.
	Per cent.	*Pounds.*				
Alfalfa 201	52.0	28.7	$4.63	$19.21	93,910	2
Alfalfa 20	73.6	20.3	3.07	13.58	238,750	5
Alfalfa 215	66.3	22.5	3.63	15.00	313,730	7
Alfalfa 227	42.0	35.7	5.75	23.80	167,470	3
Alfalfa 267	20.3	73.9	11.92	49.26	4,241,950	105
Alfalfa standard	83.3	15.0	2.42	12.00	....	....
English bluegrass 284	49.3	105.4	1.05	4.05	820,240	....
English bluegrass 375	43.4	120.0	12.00	4.80	36,000	....
English bluegrass standard	80.7	50.0	5.00	2.47	....	....
Brome grass 107	49.5	50.0	3.85	3.00	157,000	....
Brome grass 229	32.4	77.0	8.25	4.65	207,900	....
Brome grass standard	67.5	25.0	2.68	2.38	....	....

It is believed that seed market conditions will not be improved without legislation, and it is pointed out that a law excluding from sale any seed with a percentage of germination below 76 would make a saving of at least 10 per cent each year, or of a total amount of nearly $22,000 on forage crops alone. A seed law proposed for the State requires a guaranty of 85 per cent of germination and imposes a tax of one-fifth of a cent on all seed packets less than 1 pound and of one-fifth of a cent per pound for all seed in bulk, and it is estimated that the operation of this law would save the State of Kansas 14 per cent net annually in cost of alfalfa seed and 25 per cent net in all other forage crops over and above the tax.

SELECTION FOR DISEASE-RESISTANT CLOVER.[a]

For a number of years the culture of red clover in Tennessee has been uncertain on account of a fungus disease which attacks the crop. In some parts of the State this disease has become so severe that clover growing has been practically abandoned. The disease has also appeared in Virginia, West Virginia, Kentucky, and Arkansas, and is found to occur on alfalfa as well as on red clover.

In 1905 Professors Bain and Essary, of the Tennessee Station, began to investigate this problem and found the trouble to be due to an undescribed fungus disease, a form of anthracnose. The fungus causing the disease belongs to the genus Colletotrichum, and was named *Colletotrichum trifolii.* The trouble occurs in new as well as in old fields of clover, but is usually the more severe where clover has been grown for some time. In many instances this disease almost entirely kills out a good stand in one season. As spraying methods, disinfection of seed, and methods of cultivation promised little toward finding a remedy, all efforts were concentrated on the production of a disease-resistant strain of clover by selection, and the results of the first year's work, which seemed very encouraging, are presented in a recent bulletin of the station.

During August and September of 1905, at which time most of the disease-infected clover had died, over 200 isolated healthy plants, having withstood the attack of the disease on badly infected fields, were selected and the seed of each individual plant kept separate. The seed was planted in rows 18 inches apart, and the select rows were alternated with ordinary commercial clover seed. On the land used for the purpose the disease had totally destroyed the clover crop in 1905, and in order that it might again prevail in 1906 the ground was only thoroughly disked, as it was thought that plowing would cover the germs too deeply. After the clover had been up five weeks a load of dead clover raked up from a field destroyed by the fungus was scattered over the plat, putting practically every plant in direct contact with this infected material. On July 15 the dead and diseased plants from the nonselect rows were scattered over the selections as a further source of infection. Insect ravages reduced the number of plants to a considerable extent, but enough were saved to continue the experiment. Careful cultivation induced vigorous growth until June 1, when the plants from the commercial seed showed signs of the disease. By June 20 the unselected rows were blackened and dying, while the select rows alternating with them were almost perfectly healthy and normal. The entire plat had been mowed off between July 9 and September 14, in order to simulate actual cultural conditions.

---

[a] Compiled from Tennessee Sta. Bul. 75.

It was estimated that of the select plants 95 per cent lived up to the end of this period, while of the nonselect plants not more than 5 per cent survived. While the selections nearly all made a fair average growth, many showed lesions of the disease by September 14, but a good crop of stems, leaves, and seed was obtained, and a satisfactory number of plants were exceptionally vigorous and without a trace of the anthracnose. A number of plants of both select and nonselect parentage died during the winter, but on the whole the selections were decidedly the more healthy in appearance. Basing the estimate on the percentage of surviving plants of each group to the approximate number of that group which germinated, the odds in favor of the selections appeared as 50 to 1.

The authors have found this disease on alsike clover in only one case, a seedling growing in the greenhouse. To study the life history of the fungus a number of flowerpots were seeded July 12 with red clover, alsike clover, and alfalfa. On July 22 these plants, after having made a vigorous growth for some days, became accidentally infected. The red clover and alfalfa seedlings succumbed rapidly to the disease, but the alsike clover seedlings proved immune. A few surviving plants of red clover and alfalfa were probably resistant to the disease.

The most important result of the above-described experiments is the striking indication of disease resistance shown by select individual red clover plants. Since every opportunity existed for the infection of the plants from select seed, and they were subjected to the most rigid test for susceptibility to disease, there is very strong indication, at least, that success will attend the effort being made to produce an anthracnose-resistant clover. The evidence may be briefly stated thus: Certain clover plants growing in 1905, surrounded by great numbers of other plants killed by anthracnose, produced offspring which, in turn, also resisted the disease alongside nonselect plants which were killed by the disease. Of course it remains to be seen whether the next and subsequent generations will likewise resist the disease.

ERADICATION OF WILD MUSTARD.[a]

Wild mustard is a well known and very widely distributed weed pest and [illegible] which it is very difficult to eradicate when once introduced [illegible] Moo[illegible] and [illegible] the Wisconsin Experiment [illegible] successful recently in destroying [illegible] solution of iron sulphate.

[illegible] of iron sulphate into an [illegible] are gauged for approximately that [illegible] into solution. Iron sulphate is in a [illegible] or sugar [illegible] goes into solution readily. When [illegible] tes the sulphate is dissolved. Made in the proportion [illegible] ture was practically a 20 per cent solution, the proper strength, although some German experimenters have had good results by using a 15 per cent solution.

---

[a] [illegible] Wisconsin Sta. Rpt. 1906, p. 259.

The solution was sprayed on an oat field badly infested with the weed when the plants were in the third or fourth leaf. The results show that in all cases practically all of the weeds were destroyed.

The spraying should be done on a calm, bright day, after the dew has disappeared, as the work is more effective if the solution is put on in the warm sunlight. When rain follows the spraying within a few hours the extermination of the mustard will not be complete.

The grain fields should be sprayed when the mustard plants are in the third leaf, or before the plants are in blossom, in order to have the spray do the most effective work. The day following the spraying the tips of the blades of grain may be somewhat blackened, but no detrimental effects can be noticed, either to the crop or grasses seeded with it, two weeks after spraying.

Daisies, cocklebur, bindweed, ragweed, chicory, sheep sorrel, yellow dock, wild lettuce, and many other weeds were partially or wholly eradicated from the fields where tests were made for the extermination of mustard.

Iron sulphate can be purchased for about $11 per ton in small quantities and in bulk for considerably less. One hundred pounds of iron sulphate will make sufficient solution of the proper strength to spray approximately 1 acre. From 20 to 25 acres of land can be covered in a day where the sprayer is kept in continual use.

The iron sulphate solution is not poisonous and can be readily handled without injury. White clothing coming in contact with it will be discolored, but not burned.

STERILIZATION OF SOILS FOR THE PREVENTION OF DISEASES OF PLANTS.[a]

Growers of lettuce, cucumbers, tomatoes, carnations, violets, and other plants under glass and of plants in seed beds often find the plants suddenly dying while their foliage seems to be fresh and vigorous. This is especially true of plants in their seedling stage, and a careful examination will show that they are affected at or below the surface of the soil. The causes of the trouble are certain soil fungi and minute worms, called eelworms or nematodes. Where it is possible to renew the soil in the beds every season comparatively little loss will be met with, provided the soil is not infested when put in the beds. When the same soil is used season after season it is likely to become so filled with fungi and nematodes that the production of healthy, stocky plants will be impossible. The fungi, which are usually sterile, are present as minute threads or mycelia and the nematodes as active worms or as eggs and encysted or dormant forms. The fungi enter the plant through the roots and cause various forms of drop, wilt, and rot, while the nematodes cause galls on the roots and thus interfere with their function as absorbers and conveyors of water and mineral matter to the plant.

---

[a] Compiled from Connecticut State Sta. Rpt. 1897, p. 310; Massachusetts Sta. Bul. 55; Rpts. 1898, p. 149; 1899, p. 59; 1901, p. 74; 1902, p. 38; 1904, p. 10; Ohio Sta. Bul. 73, Circs. 57 and 59. For previous articles on this subject see U. S. Dept. Agr., Farmers' Buls. 186, p. 8, and 259, p. 9.

Drying and freezing have comparatively little effect upon these parasites and spraying the foliage with fungicides will be of no value, since it does not reach the seat of the trouble. Fortunately it is possible to almost wholly prevent the injury due to these parasites by the sterilization of the soil, either by heat or by chemical treatment. The old practice of burning brush and other material over the site of the tobacco seed beds unconsciously secured sterilization, although by many the benefit was attributed to the presence of the ashes. Heating the soil in any way, provided it is thoroughly done, will destroy fungi and nematodes. Dry heating and burning are not always convenient or advisable, but sterilization by the application of steam is entirely practicable. This can be done in boxes especially designed for the purpose or may be effected by leading perforated steam pipes through the beds.

The box method is fully described by G. E. Stone, of the Massachusetts Station, and W. E. Britton, of the Connecticut State Station, and consists essentially of tight zinc-lined boxes into which steam can be admitted under pressure, and the soil is held in shallow trays with galvanized-iron netting bottoms. Space is allowed between and around the trays, and an exposure of one hour to steam will destroy all nematodes and most fungi and their spores as well as any weed seed that may be in the soil. After exposure to the steam the soil can be spread in the beds and seeded as soon as convenient.

Doctor Stone and others have shown that as a rule seed germinates more quickly and plants develop better in sterilized than in unsterilized soil. The reason for this was studied by Schulze[a], a German investigator, who found that while during sterilization there were formed some decomposition products which are injurious to a certain extent for a time, these disappear after the lapse of a few days or are corrected by the addition of a small quantity of lime, and there was always an increase in the amount of available nitrogen present in sterilized soil due to the action of heat on the soil compounds, so that while [illegible] growth in sterilized soil may be retarded for a short time the [illegible] ultimately become more vigorous and the total growth is decidedly greater [illegible] sterilized soils.

[illegible] benches [illegible] subirrigation the steam [illegible] sterilization will be nominal. [illegible] through perforated iron [illegible] estimated at about $8 per [illegible] apparatus the cost could be [illegible]

[illegible] been found that certain chem- [illegible] sterilizing it. A. D. Selby, of the Ohio Station, has found that formalin or formaldehyde applied to the soil in a strength of 2 pints of formalin to 50 gallons of water is quite efficient for the destruction of fungi and active nematodes, although it does not destroy the nematode eggs or encysted forms. For these steaming is best. To treat soil with formalin it should be prepared as for seeding, and after being well raked and in a friable condition it is drenched with the solution as given above at the rate of about 1 gallon per square foot of surface. A bed 50 feet long by 6 feet wide would require about 300 gallons of the mixture containing from 12 to 15 pints of formalin. This would cost from $1.80 to $2.25 in carboy lots. If applied to seed beds in the fall before freezing weather sets in this treatment will keep down all forms of rot, damping off, and similar plant diseases.

---

[a] [illegible] 1906). No. 1–2, pp. 137–147.

PRODUCTION OF SEEDLESS TOMATOES.[a]

The production of any vegetable novelty always arouses interest among seed growers and gardeners. More or less of this work has been done by the experiment stations. For a number of years breeding experiments with vegetables have been carried on by Professor Halsted and his associates at the New Jersey stations. Among the distinct and valuable productions secured in this work is a nearly seedless tomato. As is well known, each fruit of the ordinary tomato contains hundreds of seeds, while the form which Professor Halsted has developed seldom contains more than fifty seeds and frequently there are not more than five or six and often none.

This variety has become pretty well established now and has been called the Giant because of the very large size that the plant attains. It originated five or six years ago as a result of a cross of Golden Sunrise upon Dwarf Champion.

> The seedlings frequently bear three cotyledons, and the plants are very slow, growing long stemmed, with the foliage open, due to the long internodes, and leaves with the divisions widely separated, which are crinkled, and the terminal leaflet blunt pointed. The flower clusters are small, flowers cup shaped, light lemon yellow, and the fruits few, medium small, light yellow, and nearly seedless. The flesh is particularly fine flavored. The plants, 3 feet apart each way, covered the ground devoted to the block, and flowered up to the killing frosts near November 1.

The type appears to be well fixed. Attempts to cross other sorts upon it have uniformly failed.

Seedless fruits have also been produced by Professor Halsted on several varieties and crosses of tomatoes, due probably primarily to nonpollination with other conditions favorable to the stimulation of fruit production. These crosses were quite uniformly dwarfed in size, many in a cluster being not larger than peas, but solid fleshed, and often of good quality. In one instance the fruit had the flavor of the strawberry. Currant crossed upon Stone produced such fruit, likewise Crimson Cushion upon Sumatra. When Crimson Cushion was crossed upon Giant and Magnus many seedless fruits were produced, some of which were large enough for table use. Cuttings taken from plants which produced numerous seedless fruits of this sort when planted out in the garden gave only normal fruits.

---

[a] Compiled from New Jersey Stas. Rpts. 1901, p. 442; 1903, p. 492; 1904, p. 491; 1905, p. 468; Wisconsin Sta. Rpt., 1905, p. 300.

E. P. Sandsten, working at the Wisconsin Station, produced seedless tomatoes by an entirely different method, i. e., the use of excessive amounts of fertilizers. He worked in the greenhouse with a good potting soil, using commercial fertilizers at the rate of 800 pounds of nitrate of soda, 600 pounds of sulphate of potash, and 1,000 pounds of desiccated bone per acre. Many abnormalities in the growth of the plants and fruit were observed. "In almost all cases there was a tendency of the plants to produce fruits containing a much smaller number of seeds than is generally found in the ordinary fruit." In one instance the plant was dwarfed and the fruit not larger than a walnut, but firm fleshed and entirely seedless. Another plant produced a large solid fruit that was seedless. Cuttings taken from these plants and set outdoors remained true to type, but produced more and larger fruit than in the greenhouse.

We thus have at least two ways of securing seedlessness in tomatoes—by crossing and selection and by high feeding with fertilizers. The work with seedless tomatoes at both these stations is being continued and promises to result in the establishment of varieties with far less seeds in than the sorts commonly grown. It brings out strikingly the variations that may occur in plants as a result of crossing and high feeding with fertilizers.

PICKLING OLIVES AND MOCK OLIVES FOR HOME USE.[a]

In California, Arizona, and other States where olives can be grown successfully many housewives are interested in pickling them by household methods fo[illegible] use. According to experiments carried on at th[illegible] Skinner this can be successfully done.

[illegible] best results in home pick[illegible] 'The Mission holds its color [illegible] care in the extracting [illegible] good flavor. The Man[illegible] the fruit is of a finer [illegible]ent; nor is the color of [illegible]'

---

[a] [illegible], California Cir. 24, Wisconsin Sta. Bul. 136.

[illegible] 122, p. 16.

The olives, either green or ripe, should be picked into pails about one-third full of water, to prevent bruising, and sorted as to size and ripeness. The fruit is then placed in suitable vessels (preferably stone jars, though wooden kegs, etc., may be used if sterilized so that they are free from mold spores), the water poured off, and the fruit covered with a solution made of 2 ounces of soda lye, 1 ounce of lime, and 1 ounce of common salt to a gallon of water. The solution should be thoroughly mixed and allowed to stand an hour before using, and is best if made of boiled and cooled water. It should stand about 2 inches above the fruit, and if any of the olives float it is necessary to cover them with a board and weight.

The time of the lye treatment varies from three to seven days, according to the variety, size, and ripeness of the fruit. The solution should be examined daily, and should the sleek, soapy feeling peculiar to lye disappear, it indicates that the solution is exhausted. The old solution should therefore be poured off and new solution added. It should also be changed at once should any scum or mold appear. The fruit should be frequently examined, always sampling the largest olives by cutting away a portion with a sharp knife. The progress of the lye toward the interior of the fruit is plainly marked by a distinct dark ring. When the ring has reached almost but not quite to the pit, it is time to remove the lye and commence the washing.

The lye should now be poured off and water added and renewed morning and night. The wash water should also be boiled as a preventive of mold, which is very likely to develop at this stage of the pickling process. The fruit should be kept in water, as before, with the board and weight, and throughout the extraction, washing, and salting the vessel should be closely covered. It will require from four to seven days to remove all traces of the alkali. Washing should be continued as long as the fruit has the peculiar hot taste due to the presence of lye, and it is well to test it with red litmus paper, which will turn blue if a trace of the lye remains. If the olives are still bitter after the washing has been completed, they should receive a second treatment with lye, followed by washing.

When free from lye the olives are ready for salting, the brine being composed of 2 ounces of common salt to a gallon of water. It should be thoroughly boiled, cooled, and poured over the olives. The next day this solution should be poured off and a solution containing 4 ounces of salt should be used. "If the stronger solution is used to begin with, the olives will shrivel. The fruit should next be treated with an 8-ounce brine, and if intended to keep for some time, finally with a brine containing 14 ounces of salt to the gallon. A 14-ounce brine, however, makes the olives too salty to be used without a slight soaking."

In the author's opinion, a better method of keeping the finished product is to process the olives after adding the 8-ounce brine. Glass fruit jars filled with olives and brine, with the covers lightly screwed down over the rubbers, are stood in water in a tin wash boiler and heated to 175° F. for thirty minutes. They should be then removed and the covers quickly tightened. "By this process the flavor of the olive is not injured, and if properly done the fruit will keep at least several months without deteriorating."

Mrs. L. H. Adams and E. P. Sandsten, of the Wisconsin Experiment Station, in a recent bulletin state that mock olives can be made for home use from unripe plums. According to the directions which they give, the plums when just beginning to ripen, but still green, should be pickled in a brine strong enough to hold up an egg; the brine may be made from sea salt, or, if this is not convenient, from common rock salt. The brine should be poured, hot, over the fruit and allowed to stand for twenty-four hours. It should then be poured off and the fruit placed in a new brine, boiled for one minute, and sealed in the hot brine in suitable jars.

THE HAY BOX OR FIRELESS COOKER.[a]

Considerable interest has been manifested recently in a system of cookery in practice in Norway and other parts of Europe, in which boiling hot food in tightly covered receptacles is packed in some nonconducting material in such a way that it keeps hot for a long time and slowly cooks. As hay is commonly used in Europe as a packing, the cooker is frequently called a "hay box cooker." Sometimes it is spoken of as a "Norwegian nest," and the name "fireless cooker" is also used. The principle involved is a simple one, namely, the retention of heat and hence the continuation of cooking by surrounding hot food with some nonconducting material.

Just when the Norwegian cooking apparatus was devised it would be hard to say, but it has been in use for a long time and in 1867 excited considerable interest and curiosity when it was shown as a part of the Scandinavian exhibit at the Paris Exposition. W. Mattieu Williams[b] describes it in his treatise on cooking, first published a number of years ago, as being well known, and also makes reference to an experiment of Count Rumford's in which meat was cooked under [illegible] keeping it for a long time at a tempera- [illegible] boiling water. Many persons are [illegible] experiments in which eggs [illegible] eggs were placed in an earthen [illegible] tightly covered, wrapped [illegible] allowed to remain over- [illegible] says, to be "cooked to [illegible]

Comp[illegible] Reading Course for Farmers' Wives, 5. ser., 1907, No. 23, [illegible] 446; Rep[illegible] U. S. Army], 1905, p. 80; 1906, p. 14.

Chemis[illegible]

According to Williams's description, the Norwegian cooking apparatus "consists of an inner tin pot with well-fitting lid, which fits into a box, having a thick lining of ill-conducting material—such as felt, wool, or sawdust (it should be 2 or 3 inches thick, bottom and sides). A fowl, for example, is put into the tin, which is then filled up with boiling water and covered with a close-fitting cover lined like the box, and firmly strapped down. This may be left for ten or twelve hours, when the fowl will be found most delicately cooked."

From time to time articles have appeared regarding this method of preparing food, and recently considerable interest has been manifested in the subject, perhaps owing to the efforts of the German Government[a] to direct the attention of the families of small means to this device as furnishing an economical method of cookery. The popular descriptions[b] of this sort of cooker, which have appeared now and then, differ more or less in details, but the principle is always the same, namely, the retention of heat by surrounding the food with nonconducting material.

Such cookers may be readily made at home, and even when they are of very simple construction they have given good results provided they are well packed with insulating material. A tightly covered tin or enameled can or bucket or a kettle preferably without a handle, but having a tight cover, and a wooden box and packing material are the essential features. The packing box or other receptacle should be considerably larger, say 3 or 4 inches in every direction, than the vessel used for cooking. Line the box with several thicknesses of paper or with asbestos. Over the bottom of the box should be spread a thick layer of hay, crumpled newspaper, or similar material tightly packed. The cooking vessel is placed on the center of this and the spaces between it and the sides of the box packed full of the hay or whatever is used. A thick cushion or pad of suitable size should be made for covering the top of the can and a wooden cover for the box is also desirable. In some of the cookers which have been described in magazines, etc., thick felt, asbestos, cork, and other nonconducting materials have been used for packing, but good results have been reported with the simpler materials.

These cookers may be made to hold one or more cooking vessels, and in case space is desired for two or more it is convenient to divide the box into compartments.

Figure 1, which is drawn from data furnished by tests carried on at the Cornell Agricultural College and Experiment Station, in connection with home economics courses, shows a cooker suitable for two cans.

---

[a] Mo. Consular and Trade Rpts. [U. S.], 1905, Nos. 297, p. 15; 302, p. 242.

[b] Home Sci. Mag., 20 (1903), p. 9; Amer. Agr., 79 (1907), No. 1, p. 27; Everyday Housekeeping, 22 (1906), p. 816; The Hay-Box Cook Book, Chicago, 1906.

The tests at Cornell have been satisfactory and the hay box cooker "is recommended to housewives as a means of saving fuel and securing good results in cooking cereals, chicken, macaroni, or anything requiring long, slow cooking or steaming."

The food which is to be cooked is brought to the boiling point in the can or bucket and cooked for a short time, two or three to twenty minutes usually, or perhaps ten minutes on an average (though the time depends upon the material and should be learned by experience), and is tightly covered and placed in the nest and covered on top with the cushion and the lid of the box closed. The cool air of the room can not pass through the packing to the can nor can the heat inside it pass through the nonconducting material, except very slowly, and so the food remains hot for several hours and cooks thoroughly and evenly without further attention. According to the Cornell report, "about twice as much time is required as in cooking over the flame. There is little evaporation. Consequently, care must be taken not to use too much water in preparation. Many articles of food are better for long, slow cooking, and as neither fire nor attention is needed (after the initial heating) it proves an economical means of preparing food for the table." An advantage claimed for the hay box cooker is that there are no noticeable odors from the cooking food.

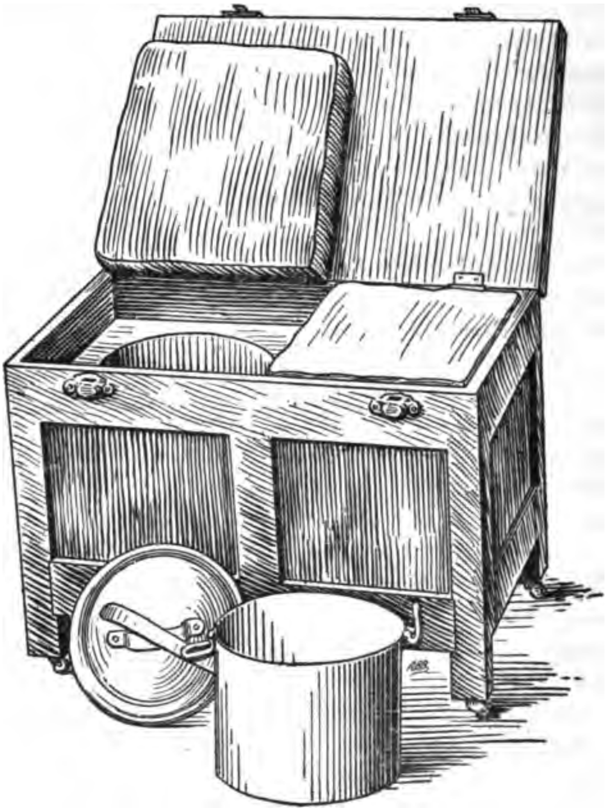


FIG. 1.--Hay box or fireless cooker.

The cooker must not be opened from the time the food is placed in it until it is needed for serving, as the removal of the covering, etc., would mean an escape of heat.

Cookers constructed on the principle outlined have been tested for several years by the Commissary Department of the United States Army and have given good satisfaction, particularly for the preparation of rations for soldiers on the march. According to the reports of the Commissary-General, the cookers used are of large size and special attention is given to packing materials and other factors so as to insure the insulation of the containers in which the food is cooked. The meat, beans, cereal, or other food is heated in the can at breakfast time, packed, and carried in carts with the other camp equipment while the men are on the march, and when camp is reached at night a hot soup or other dish is ready without the delay attendant on cooking a hot meal in the usual way.

In this system of cookery the food is kept on the stove for only a short time, and hence only a small amount of fuel is required, and it has a further advantage in that it does not heat the rooms in which the cooking is done.

By means of this cooker a breakfast cereal may be prepared by boiling it a few minutes in the evening, then packing it away in the cooker, and in the morning it will be ready for use. Soup can be prepared early in the day and will be ready for luncheon without any further attention. In the descriptions of the hay box cited above and other similar publications the writers, on the basis of personal experience, give directions for the preparation of vegetables, meats, soups, desserts, and other dishes, and the consensus of opinion seems to be that the hay box cooker is a convenient. economical, and labor-saving device.

COMBATING INSECT ENEMIES OF SHADE TREES.[a]

In recent years more and more attention has been given by municipal authorities to the condition of shade trees within the city limits. A number of insect pests of prime importance have attacked trees used for shade purposes in cities, and where no attention has been given to these pests they have often completely defoliated even the largest shade trees along the streets and in city parks.

At first it was considered difficult, if not impossible, to apply direct insecticide treatment to tall elms and other shade trees. Prof. J. B. Smith, of the New Jersey Station, however, showed that if a strong barrel pump were used and a bamboo extension pole attached to the hose for holding the nozzle as far as possible from the ground, trees of moderate size could be readily sprayed with insecticides. Since that time various power sprayers have been put in operation by means of which sprays may be thrown to the top of the tallest shade trees. Since the most serious shade-tree insects feed upon the foliage and may, therefore, be destroyed by the use of arsenicals, it becomes merely a matter of civic pride whether suitable means will be put in operation for protecting shade trees. It has been estimated by Doctor Howard that with an expense of $4,000 or $5,000 annually almost any city in the United States may keep the foliage of its shade trees in a green condition throughout the growing season.

---

[a] Compiled from Illinois Sta. Bul. 112; Kentucky Sta. Bul. 120; Massachusetts Sta. Bul. 114; New Hampshire Sta. Bul. 128; New York Cornell Sta. Bul. 233; U. S. Dept. Agr., Farmers' Bul. 99.

Great differences have been noted in the susceptibility of various species of shade trees to insect attacks. The least susceptible is the ginkgo, which in this country has not been attacked by any serious insect pest. The tulip tree is almost equally free from insects, although plant lice and gall midges may disfigure the leaves to some extent. It is not practicable, however, to plant in all cities only those trees which are free from insect pests. Strong preferences are held by the citizens of different municipalities for elms, maples, lindens, and other well-known shade trees which are more or less seriously attacked by insects. In order to protect their foliage from destruction during the growing season it is necessary, according to the experience already had in various cities, to place the work of insect control on shade trees in the hands of a city forester or superintendent of parks.

Among the most serious insect enemies of shade trees are the elm leaf-beetle, tussock moth, bagworm, fall webworm, brown-tail moth, gipsy moth, cottonwood leaf-beetle, and cottony maple scale. Recently the oriental moth has been discovered in Boston and threatens injury to shade trees. All of these insects except the cottony maple scale may be destroyed by spraying the foliage with arsenicals, especially arsenate of lead. The first application may be made immediately after the buds have opened and further treatment may be regulated according to the abundance of leaf-eating insects in any given locality. Most of the pests mentioned in the list of important shade-tree insects are open to other methods of attack. Thus, the winter nests of the brown-tail moth should be destroyed before the insects become scattered [illegible] the spring. The gipsy moth may be captured by band[illegible] will be greatly reduced by destroying [illegible] leaf-beetle in the larval condi- [illegible] the trees by spraying with [illegible] the tussock moth are con- [illegible] destroyed.

[illegible] have been reported dur- [illegible] Chicago and other cities. This [illegible] insecticides, among which kero- [illegible] The cottony maple scale [illegible] linden, box elder, elm, and honey locust. In a series of experiments carried out by Professor Forbes, of the Illinois Experiment Station, it was found that the most useful insecticide for the control of this pest was kerosene emulsion, which, if applied in summer, should not contain more than 10 to 12 per cent of kerosene, and if used in winter not more than 16 to 18 per cent. It is recommended that the first summer application be made when about half of the eggs are hatched and the second just at the end of the hatching period. As a rule, however, a thorough winter application of the stronger kerosene emulsion is more effective than the summer treatment.

FEEDING WHOLE GRAIN.[a]

In ordinary digestion experiments with farm animals the proportions of nutritive materials remaining in the feces are determined by chemical analysis, and such data are of course admirably adapted for the study of many problems.

A mechanical method of separating the undigested from the digested material is sometimes followed in the study of various practical questions connected with animal feeding. It is customary in such tests to mix the manure with large quantities of water, which washes away the metabolic products and similar materials and leaves the undigested grain behind. The fact that the manure may contain considerable undigested material receives practical recognition in animal feeding. Pigs are very commonly allowed to follow fattening steers in order that they may gather and utilize this food which would otherwise be wasted.

In tests undertaken at the Kansas Station to determine the relative amounts of soaked and dry corn thus available for pig feeding, the droppings from two lots of steers were gathered for twenty-eight days. The undigested corn was carefully washed out from the feces and weighed and it was found that the steers fed the soaked corn failed to digest 11 per cent of the 3,045 pounds eaten and those fed the dry corn 16 per cent of the 3,060 pounds eaten. The grains compared in a later test at the Kansas Station, which covered thirty-three days, included corn meal, red Kafir corn meal, and white Kafir corn meal. Washing away the digested material from the undigested showed that 5.5 per cent of the corn meal, 11.3 per cent of the red Kafir corn meal, and 14.1 per cent of the white Kafir corn meal passed through the animals undigested. The utilization of the undigested material by pigs was one of the principal features studied in both of these tests.

A recently published bulletin of the Michigan Station reports the results of a study undertaken to determine the proportion of whole corn, whole oats, and a mixture of these grains which escaped digestion when fed to cattle. According to R. S. Shaw and H. W. Norton, jr., who carried on this work—

---

[a] Compiled from Kansas Sta. Buls. 47 and 67; Michigan Sta. Bul. 242.

> For some time past the system of feeding whole grain has had many advocates. Some speakers and writers on agricultural and live-stock subjects have advised the use of whole corn either alone or in conjunction with other grains for steer feeding, and many farmers are feeding whole oats to cows, young stock, and calves.
>
> The presence of large quantities of oats in the droppings from cows fed a grain mixture containing whole oats, and the fact that a field manured with these droppings produced a fairly good stand of oats suggested an experiment to determine the percentage of whole grain passing through the digestive tract. * * *
>
> Claims are also made by advocates of this method of feeding that even though a large amount does pass through without apparent change still the animal "gets a lot of good out of it." To clear up this last question chemical analyses were made to find the exact composition of the grain both before and after feeding in order to detect any changes taking place. * * *
>
> No attempt was made to compare the feeding value of whole grain with ground grain, nor was any attempt made to ascertain the gains or losses in weight made by the animals while on the whole-grain feed.

Each of the grain rations was tested with lots containing two cows, two heifers, and two calves, the feeding period covering seven days.

> All grain fed was weighed and all droppings collected and washed through screens to separate the grain. The screens were as fine meshed as could be used and still allow the escape of everything but the grain; in fact some of the oats were washed through and lost. * * * The grain was then spread out in a warm room and dried and run through a fanning mill to clear from straw and chaff and was finally weighed. Samples were taken for chemical analyses.

The following table shows the proportion of the grain eaten which was recovered whole in the feces:

Proportion of grain eaten recovered whole in the feces; experiments with cattle.

Kind of animal.	Whole corn recovered.	Whole oats recovered.	Whole corn and oats recovered.
	Per cent.	*Per cent.*	*Per cent.*
Cows	22.75	12.06	26.46
Heifers	10.77	5.48	17.50
Calves	6.28	2.98	5.78

It will be noted that in every case smaller quantities of undigested grain were found in the droppings of the younger animals and that the proportion of corn which escaped digestion was greater than that of oats.

> Chemical analyses showed practically the same composition of grain as before feeding; therefore it is safe to conclude that the animal derives no benefit from grain which passes through the digestive tract unmasticated.
>
> The germinating power of the grain passing through the system was affected very markedly but not entirely destroyed, as 4.3 per cent of the corn and 10.6 per cent of the oats germinated after this treatment.

The data reported are not sufficient for general deductions as to the relative merits of whole and ground grain or soaked and dry grain, but they do clearly show that in ordinary methods of feeding the proportion of grain which escapes digestion may be considerable. It is a matter of experience that cattle fed large grain rations toward the close of a fattening period digest such feed less completely than animals eating smaller quantities. Factors like the above should receive consideration in regulating the number of pigs following fattening steers and other questions connected with animal feeding, in order that the greatest profits may be secured.

The length of time which grain remains in the digestive tract was one of the questions considered in the tests at the Kansas Station. On one day of a feeding period red Kafir corn was substituted for the white Kafir corn which made up the grain portion of the ration. On the day immediately following it was found that red kernels began to appear in the manure and the maximum number was noted on the afternoon of the second day. They then began to decrease, and on the fourth day only a few red kernels were found in the washings.

THE IMPROVEMENT OF CATTLE.[a]

The Michigan Experiment Station has begun animal-breeding experiments, and a recently published general discussion of breeding problems by R. S. Shaw is the outcome of this work. In Professor Shaw's opinion very many Michigan cattle breeders raise inferior milch cows and steers, the chief fault of the common cattle being a lack of quality and uniformity, which is due not so much to lack of the infusion of good blood as to the indiscriminate admixture of beef and dairy types.

> With the rise in prices of dairy products, the common cows have been bred to dairy bulls; with depreciated values for dairy products, these same cows and their female progeny have been bred back to beef sires, and so on. On the other hand, there are plenty of instances where herds possessed of cows of a small type, producing a small flow of rich milk, have been bred to a bull of a larger breed noted for heavy milk flow, and vice versa.

In urging that widespread attention be paid by Michigan cattle raisers to improvements in dairy and beef herds, a number of general deductions are drawn regarding some of the more important phases of cattle breeding. In the author's opinion live stock improvement is not difficult.

> Questions of breeding are generally regarded as being obscure, intricate, and extremely difficult, except to those skilled in the art through long years of training. * * * But the initial step in live-stock breeding for improvement confronting us to-day is an exceedingly simple one; we do not need to undertake the establishment of new types or breeds, as there are plenty now in existence to choose from which, judiciously chosen, will respond favorably to the conditions to which they are adapted. The first step in the line of live-stock improvement must come from the cessation of the practice of admixing the blood of the various breeds and of using grade and scrub sires.

---

[a] Compiled from Michigan Sta. Bul. 241.

The plan we have to suggest [for the upgrading of herds] and discuss for the improvement of the common stocks of the country is that known as upgrading, which consists in ingrafting the characteristics of a superior breed upon animals of common or mixed breeding for the purpose of improving them. This improvement is due to the superior quality of the males used and chiefly their prepotency or power of transmitting accurately these qualities to their offspring. This plan differs from crossbreeding in that pure blood is used on the sire's side and females of mixed blood or no blood on the dam's side. Thus we have the prepotency concentrated in the bull and the very opposite in the females, as the more mixed the breeding the less stable are the inherent characteristics of the individual, and therefore the less resistant to improvement.

It would be absolutely impracticable to advise all owners of common cattle to send their stocks to the block and purchase pure-bred foundation stocks; only a few could do this for the following reasons: First, if the great majority now possessed of common stocks were to simultaneously seek to purchase pure-bred foundation stocks, they could not get them; they are not in existence, for only about 1 per cent of the cattle in the United States are possessed of pedigrees. Second, the finances of a great many holders of common stock are not such as to allow them to make extensive purchases of pedigreed animals and replacement is out of the question, as it would require the returns from the sale of three or four common animals to purchase one pedigreed one. Third, it is highly desirable for breeders to grow into any line of pure breeding rather than to buy into it suddenly and take up a work in which experience is necessary.

In general, then, it is necessary for the majority of holders of common stock to make the best use of the animals on hand with a view to improving them. Let us suppose the case of a herd of common or mixed cattle of, say, 18 head and apply a plan of improvement. The first thing for the owner of this herd to do is to decide upon some one line of production, either beef or dairy, and then stand by the resolution. Without this he can not improve his herd, for the animals of mixed breeding are largely the result of frequent change of purpose. Suppose in this case that the owner has decided to go into the dairy business; that being the case, the next thing to do will be to look over the herd of 18 and decide which ones are so possessed of dairy type and characteristics as to warrant their being used in the business. They can be divided into three classes—such as best, medium, and inferior—from a dairy standpoint. Then, in the majority of cases, it will be found to be a decided advantage to send the 6 inferior ones to the block and use the remaining 12 for the foundation herd. Having selected the females to be retained, the next and one of the most important steps is to decide upon the breed to be used in improvement. In this, adaptability of the breed to the conditions and the question of personal preference, are the two important factors; the decision of this question is also an important factor, for a change of mind after the work has begun and the use of other blood is more apt to result in retrogression for a time than improvement. Having decided upon the breed to be used for improvement, suppose it is the Holstein, then purchase the [illegible] will allow. Mate this bull with the 12 [illegible] after which his progeny will be old enough [illegible] other Holstein bull, a better one than the first if [illegible] and indefinitely. Let it be Holstein [illegible] Holstein bulls. We have cited the Holstein [illegible] the plan must be used no matter [illegible]

[illegible] that the use of improved methods of [illegible] necessary for these to be supple- [illegible] management.

[illegible] important bearing on their value [illegible]

In general, it can scarcely be said of a bull that he has reached full maturity until 4 years of age, though this perfect stage of development is commonly regarded as being attained at a somewhat earlier age among some breeds. It has been a common practice for years among farmers to send the 3 or 4 year old bulls to the block, largely because there is no sale for them as breeders. The general rule among prospective purchasers is to search for nothing but young bulls—yearlings or less—with the idea that they will grow into money for them, if they can dispose of them before maturity. * * *

There are some decided advantages in purchasing mature bulls. One of the greatest of these is found in the fact that the buyer can ascertain something relative to the character of their get. This is most important to the breeder of dairy stock. Another advantage arises from the fact that there is always more or less uncertainty regarding the future development of the bull calf, while this factor is entirely eliminated in the purchase of a mature sire. It is also not unreasonable to conclude that a mature sire will beget more vigorous offspring, especially because the young ones are frequently used to excess. Three and 4 year old bulls can generally be secured at very reasonable prices.

During the past decade or two there has been a growing tendency to breed heifers at an early age. This is particularly true among the dairy breeds. * * *

While it is clearly apparent that immature breeding has reduced the size of many of our dairy cattle, it has not been proven that diminished constitutional vigor has accompanied this loss of size, though many hold to that view. It is rational to assume that in unduly immature breeding some of the physiological laws of nature must be violated, and this can not occur without being followed by some evil results. No fixed age can be given for the breeding of heifers. It should be dependent on the rapidity and character of the development of the individual.

As regards grades versus pure breeds, "high-grade animals may be eventually produced capable of equaling those of the pure breed used in their improvement in so far as meat or milk production are concerned, but at the same time they can never equal them in prepotency nor become possessed of pedigrees, except in rare instances."

In breeding up herds some form of cooperation, in Professor Shaw's opinion, should be established by communities, such as the joint ownership and use of males by several cattle breeders. That such cooperation has not always been successful when attempted is explainable on several grounds, but there is every reason, in his judgment, to believe that it is possible and, rightly managed, will lead to satisfactory results.

VENTILATION OF STABLES.[a]

Some experiment station work along the line of stable ventilation has been summarized in a previous bulletin of this series.[b] Many problems have arisen in connection with the ventilation of stables and have assumed such importance that the necessity for the study of the subject from all possible standpoints has been recognized. Important contributions to the subject have recently been made by M. H. Reynolds, of the Minnesota Station. The results obtained by this investigator appear to be at variance with the commonly accepted ideas of ventilation and suggest that new explanations are needed of the observed facts in cases of good and poor ventilation.

---

[a] Compiled from Minnesota Sta. Bul. 98; U. S. Dept. Agr. Yearbook 1904, pp. 216-218.

[b] U. S. Dept. Agr., Farmers' Bul. 190, p. 23.

One of the main objects of this study was to determine the effect of carbon dioxid upon animals confined in stables. In experiments with human beings in the respiration calorimeter Professor Atwater has shown that man remains apparently in perfect comfort in an atmosphere containing 2.3 per cent of carbon dioxid, or almost 80 times the quantity found in ordinary atmospheric air. The air, however, was kept pure in other respects and the amount of moisture was not unusually high. In the experiments carried out by Doctor Reynolds on cattle the air was saturated with moisture and the amount of carbon dioxid varied, being in some cases as high as 2.67 per cent, as compared with 0.03 per cent in ordinary air. Moreover, the air contained ammonia and other organic materials which may be given off in expired air.

In such an atmosphere, obtained by confining steers in a nearly air-tight box stall, steers were kept for periods varying from two to twenty-eight days. None of the bodily functions were materially disturbed, the only effects observed being a slight increase in the rate of pulse and respiration and a small elevation of temperature. The animals showed good appetite and appeared to be in perfect health and comfort during confinement. The amount of moisture in the atmosphere of the stall was so great that water ran down the sides of the stall and the walls became covered with mold. Nevertheless, animals confined under these circumstances not only appeared to remain healthy and comfortable, but gained at the rate of 1 pound per day. Even the healing process following upon dehorning seemed not to be interfered with by confinement in the moist atmosphere containing more than 80 times the normal amount of carbon dioxid.

Doctor Reynolds concludes from these experiments that the common explanation of the desirability of ventilation in stables must be revised to conform with the results which he has obtained. It is suggested that the air requirements recommended by various investigators for farm animals confined in stables are altogether too high, and, in most cases, impossible of accomplishment. These requirements vary from 14,000 to 32,000 cubic feet per hour, whereas the stall in which steers were confined during the experiments of Doctor Reynolds, contained only 784 cubic feet of air. It is urged that from the standpoint of economy and profit the fundamental problem in stable ventilation consists in determining the least amount of air change necessary to keep the animals in health and comfort. Further experiments will be carried out to determine the minimum amount of atmospheric change required for this purpose. It is suggested that a well-lighted but poorly ventilated stable is perhaps superior from a sanitary standpoint to one which is poorly lighted and well ventilated.

HOG COTS.[a]

In continuation of a previous article[b] attention is here called to two forms of portable hog houses or hog cots in use at the Wisconsin Station, which are thus described by J. G. Fuller of that station:

> The first type of cot used is represented in figure 2 and is constructed in the following manner: The framework, as the cut shows, is made by using 2 by 4's 16 feet long, sawed in the middle, thus making the bottom dimension 8 feet square, each side 8 feet square, the gable ends being thus formed with rafters 8 feet in length. The front sill is laid flatwise to interfere as little as possible with the young pigs going in and out. The frame rests on short pieces of 2 by 4's railed across each corner, which can be replaced when necessary. When a floor is desired it should be constructed on stringers and the frame made to rest thereon. The following lumber will build the house without floor:

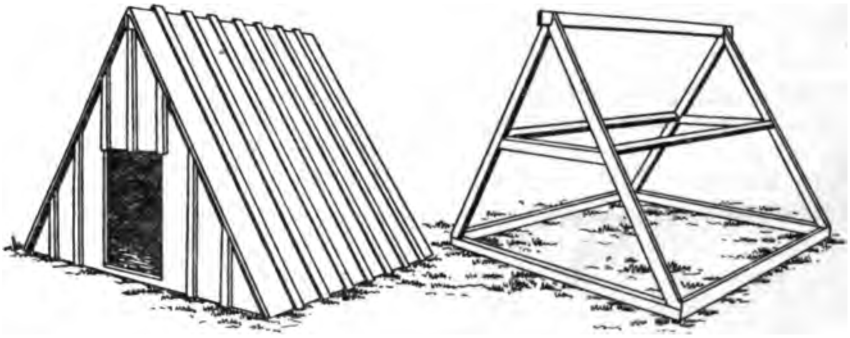


FIG. 2.—Wigwam hog cot used at Wisconsin Station.

> 13 pieces No. 1, 1 inch by 12 inches, 16 feet long.
> 6 pieces, 2 inches by 4 inches, 16 feet long.
> 10 O. G. battens, 16 feet long.
>
> Eight boards, sawed in the middle, make the sides and the remainder, the ends. A small perpendicular slide window is usually made in the rear gable for ventilation. The total cost of material for the house, as shown in the cut, without floor, amounts to practically $11.

Another type of house may be built in two sizes. The larger size, the completed structure shown in figure 3, is 8 feet wide by 10 feet long, 7 feet 2 inches high in front, and 3 feet high in the rear. The smaller house, the frame and completed structure of which are shown in figure 4, is 6 feet wide, 8 feet long, 6 feet 2 inches high in front, and 3 feet high in the rear. The construction of these houses is simple, as may be seen from figure 4.

---

[a] Compiled from Wisconsin Sta. Rpt. 1906, p. 42.
[b] U. S. Dept. Agr., Farmers' Bul. 273, p. 11.

The floor is built first, with 2 by 4's as stringers, and the frame is held on the floor by blocks at each corner. The large-sized house is provided with two doors in front and a temporary movable partition in the middle so that the cot can easily be adjusted to accommodate two lots of swine at the same time. On a level with the glass windows there is also a drop window, preferably hung on hinges, fastened at the top for ventilation and sunlight.

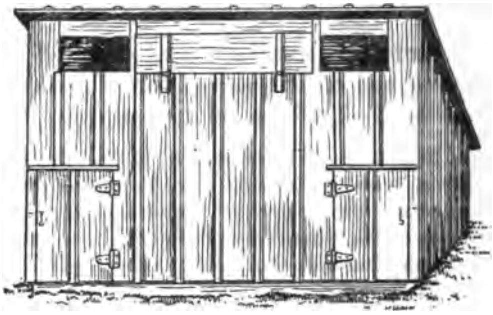


FIG. 3.—Large size hog cot.

The lumber required for the large house, 8 feet wide and 10 feet long, including floor, is as follows:

20 pieces, 2 inches by 4 inches, 10 feet long, for frame and stringers.

2 pieces, 2 inches by 4 inches, 16 feet long, for frame in ends.

20 pieces, 1 inch by 12 inches, 16 feet long, for roof and ends.

5 pieces, 1 inch by 12 inches, 16 feet long (rough), for floor.

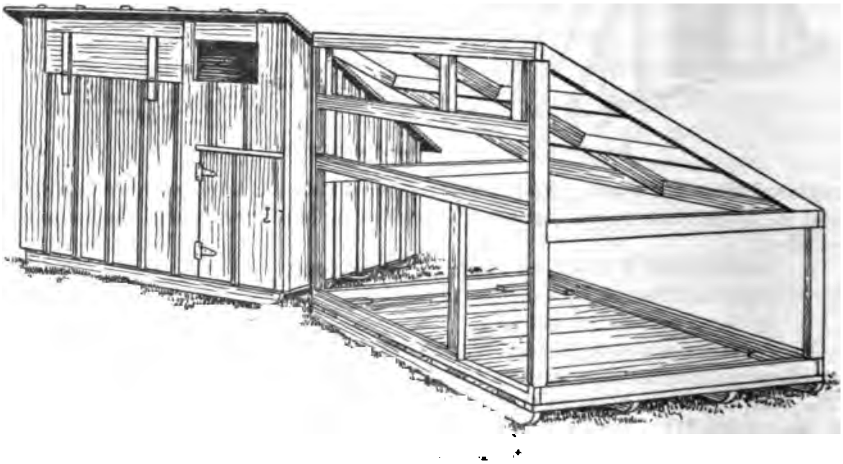
15 O. G. battens, 16 feet long, for sealing cracks between boards.

The material, including the door, hinges, and glass, will cost between $16 and $17.

The lumber required for the house 6 feet wide and 8 feet long is as follows:

12 pieces, 2 inches by 4 inches, 16 feet long, for frame.

4 pieces, 1 inch by 12 inches, 16 feet long (rough), for floor



[illegible] roof and ends.

[illegible] cracks between boards.

[illegible] with floor, door, and window com- [illegible] economy, durability, and comfort to [illegible] excellent. Where it is desirable to keep a number of [illegible] preferable. The small cot will accommodate from three [illegible] the large cot from seven to nine.

Although the Wisconsin Station has a large hog house with feed room, scales, etc., the cots have been found a convenient means of enlarging the facilities of the piggery. Of their general advantages Mr. Fuller says:

> With the cot system the farmer or breeder can enlarge his accommodations as the size of his herd increases. The mud and vermin which are sure to accumulate around a large hog house can easily be avoided with the small houses and by occasionally moving them to a fresh spot of ground. Where it is necessary to keep only a few hogs together, or where several animals must be provided with separate quarters, the cot becomes an indispensable factor, and can be used to advantage on any farm.

PRESERVING EGGS IN WATER GLASS.[a]

The experiment station literature and other published results of scientific investigations furnish evidence as to the successful use of water-glass solution for preserving eggs, and this literature has been referred to in earlier bulletins[b] of this Department.

As noted in a previous bulletin of this series[b], much of this literature is summarized by R. W. Thatcher, of the Washington Agricultural Experiment Station, and experiments are reported in which water-glass solution, a brine made of lime and salt, and a commercial egg preservative were tested. In these experiments eggs kept in good condition for home use for at least eight months when preserved either with the water-glass solution or with the lime and salt mixture, but considering cost, quality, appearance, flavor, and other characteristics, Professor Thatcher prefers the water-glass solution.

Particular interest attaches to the data recently published by J. Hendrick, of the University of Aberdeen, as he examined a very large number of eggs preserved in water glass under commercial conditions and also made special studies of the quality and composition of eggs thus preserved for long periods. In general, the preserved eggs were found to be of good quality, though they had not been preserved under the best conditions, as they were not placed in the water-glass solution on the day on which they were laid, but were collected in the country and sent into town in large lots and were two or three days old before preservation. As might have been expected, some of these eggs were bad, but the proportion was not large. In one instance out of 384 dozen eggs preserved between April and June and sold between October and December only 5 dozen, or 1.3 per cent, were bad, and the majority of these were broken or cracked eggs.

Usually the eggs which were preserved in water glass, according to Professor Hendrick—

---

[a] Compiled from Washington Sta. Bul. 71; Jour. Agr. Sci., 2 (1907), No. 1, p. 100.

[b] U. S. Dept. Agr., Farmers' Buls. 103, 128, and 273.

Have a nice appearance, as the shells are very clean and fresh looking after the water glass is wiped off them. Even those which had been several years in water glass had a fine, fresh appearance. Another advantage of preservation in water glass over certain other methods is that the contents of the egg do not shrink owing to evaporation. The eggs therefore do not rattle when shaken, no matter how old they are. The cost of preservation is very small.

It was found that eggs which had been kept in water glass for a few months could hardly be distinguished in appearance, flavor, and smell, either raw or cooked, from what are called "fresh eggs"—that is, fresh eggs in the commercial sense, which are eggs which should be free from decomposition or taint, but which may be several days old. A really fresh egg, only a few hours laid, is easily distinguished in flavor and appearance when cooked from the "fresh egg" or preserved egg, and is known as a "new-laid" egg. The eggs which had been preserved in water glass for about six months tasted and smelled like well-kept eggs a few days old. As the eggs in question were a few days old when they went into the water glass, they were not appreciably changed to my eye and palate by a few months' stay in water glass.

As the eggs get older, however, a distinct change is found which can be appreciated both by the eye and palate. Eggs which have been three or four years in water glass are easily recognized. The white becomes pink in color and very liquid. The egg acquires a slightly peculiar taste which * * * suggested soda. At the same time even when four years old the eggs had no unpleasant taste or smell, and the white coagulated in the usual manner in cooking. Though there was a slight characteristic odor when the eggs were cooked, it was not a stale or bad odor and did not suggest sulphureted hydrogen. The changes in the preserved eggs take place very gradually. At one year old they are hardly noticeable; at two years they are distinct, but not so distinct as at three or four years old.

To further test the effects of the preserving solution fresh eggs and eggs which had been kept in water glass one to three years were analyzed and it was found that there was practically no change in their composition even after lengthened immersion in the solution. Practically no silica and little, if any, soda found their way into the eggs. The eggs do not dry up and there is scarcely any change in their ash content, though they contain slightly more soda than fresh eggs. "The alkalinity of the contents of the eggs appeared to increase with the length of time they were in water glass, but the increase was small, and in a complicated substance like egg it was found difficult to measure it accurately." "The slight alteration in the flavor of the egg and in the liquidness of the white may be due to the increase in soda."

[illegible] deposited in the egg shell from [illegible]on, samples of shell and mem- [illegible] analyzed and it was found that [illegible]ved for three years amounted to [illegible] ith 0.5 per cent in the shells of [illegible] a slow deposition of silica takes [illegible] percentage of lime in the shells [illegible] deposition of silica in the shells [illegible] the shells to some extent and renders [illegible]

According to Professor Hendrick, the sirup-thick water glass, such as is used after proper dilution for egg preservation, is a sodium silicate. As shown by his analyses it does not contain sufficient soda to neutralize all the acid present, and the solution is strongly alkaline in reaction. A sample of sirup-thick water glass contained 37.91 per cent silica, 16.48 per cent soda, and 0.14 per cent potash, and a solution prepared for preserving eggs, 2.76 per cent silica, 1.20 per cent soda, and 0.01 per cent potash.

On the whole, Professor Hendrick regards the water-glass solution as one of the most popular and widely used preservatives for eggs. "Though this method was introduced only comparatively recently, it has largely superseded older methods, and also appears to have led to much more frequent preservation of eggs on the small scale in households and by small traders. The method is simple and effective. The eggs are obtained when they are plentiful and cheap in spring and preserved for use during the winter months." In such cases it is necessary to keep them for about six months, but they may be kept much longer, for in the experiments referred to above some were left in a solution of water glass as long as four years and were not decayed.

It is assumed that eggs preserved in water glass will be so labeled when offered for sale.

AMERICAN CAMEMBERT CHEESE.[a]

The genuine Camembert cheese is made in France, particularly in the northwestern part, where the industry, originating a little over a century ago in the village of Camembert, in Orne, and shifting soon into Calvados, has reached great importance. This variety of cheese is one of the most highly esteemed of the many soft kinds and has accordingly been imported to a considerable extent into the United States. It is but natural, therefore, that in keeping with the American desire to produce at home the products of all kinds that are of local demand, efforts should have been made to manufacture cheese of the Camembert type in this country.

Until recently these attempts have not been wholly successful. For about three years this Department and the Connecticut Storrs Station, in cooperation, have been investigating thoroughly the making and ripening of Camembert cheese, and in an earlier number of this series[b] has already been noted the substance of a preliminary report on this work, in which it was shown that the principal agents concerned in the ripening process are two species of molds, known technically as *Penicillium camemberti* and *Oidium lactis*.

---

[a] Compiled from Connecticut Storrs Sta. Bul. 46.

[b] U. S. Dept. Agr., Farmers' Bul. 225, p. 31.

The manufacture of the Camembert type of cheese at the Connecticut Storrs Station has now been carried on sufficiently long and with such a high degree of success that efforts to establish the enterprise on a commercial basis in this country seem abundantly warranted. To this end Director L. A. Clinton in the introduction to a recent bulletin announces that the Connecticut Storrs Station is now prepared to assist factories and individuals in making this type of cheese, and Mr. Theodore Issajeff in the body of the bulletin describes the plant and equipment necessary and gives directions for making the cheese. While anyone specially interested in making Camembert cheese should of course secure a copy of the bulletin,[a] nevertheless a brief outline of the process of manufacture as given in it and which, it may be mentioned, differs in some respects from that employed in France, may be of some general interest, and with this in view the following points are noted:

The fresh whole milk is warmed to 85° F., and a starter, preferably a pure culture of lactic-acid bacteria, is added. A rather high degree of acidity (0.30 to 0.35 per cent) is allowed to develop, and sufficient rennet (about 8 to 10 cc. per 100 pounds of milk having an acidity of 0.3 per cent) is then added to the milk at the temperature mentioned to secure the desired texture of the curd in one and one-half to two hours. The curd is cut, stirred gently, and allowed to stand for about fifteen minutes, when the bulk of the whey is removed. After being stirred thoroughly the curd is dipped into galvanized-iron forms or hoops, 4 inches in diameter and 5 inches in height and open at both ends. They rest upon a mat made of fine bamboo strips. The cheeses are allowed to drain naturally for four to five hours, when they are inoculated with cultures of the molds mentioned and turned. The next morning they are removed from the forms and salted by rubbing salt on the surface. When the curd is not cut, as is the custom in France, a higher acidity of the milk is necessary (0.40 to 0.45 per cent) and a longer period is allowed for draining. The next day after salting [illegible] cheeses are transferred to the first ripening room, which [illegible] nearly saturated with moisture and kept at a tem- [illegible] When placed on boards the cheeses are [illegible] week they are wrapped in tin foil [illegible] usual [illegible] into small round wooden boxes, [illegible] the second curing room, which [illegible] may have a lower per- [illegible] Here the cheeses remain [illegible] in the best condition for [illegible]

---

[a] [illegible] published recently as Bulletin 98 of the Bureau of [illegible] Department [illegible]

Issued May 31, 1907.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 297.

METHODS OF DESTROYING RATS.

BY

DAVID E. LANTZ,

Assistant, Bureau of Biological Survey.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF BIOLOGICAL SURVEY,
Washington, D. C., May 15, 1907

SIR: I have the honor to transmit herewith for publication Farmers' Bulle No. 297, containing concise directions for the destruction of rats, prepared David E. Lantz, an assistant in this Bureau. The damage done by these rode both in cities and in the country, is enormous, and the calls for practical meth of destroying them are correspondingly numerous and urgent. It is belie that by following the directions here given the numbers of this pest can greatly reduced and the losses from them proportionally diminished.

Respectfully,

C. HART MERRIAM,
Chief, Biological Surve

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

Pa

Introduction
Methods of destroying rats
  Poisoning
  Trapping
  Use of ferrets and dogs
  Fumigation
Rat-proof construction
Natural enemies of rats
Conclusions

ILLUSTRATION.

P

FIG. 1.—Method of baiting guillotine trap

METHODS OF DESTROYING RATS

rats and
ial preparations
experiments prove that
arsenic, it may sometimes be
INTRODU ...tive poison. Preparations of phos-
re often too weak to be effective; and
The brown or Norway hen of sufficient strength, are dangerous, as
pest in the United Sta baits into walls or crannies and thus cause fires.
to many millions other reasons the Biological Survey does not recom-
from all oth rations containing phosphorus.
destructive **In the Poultry House.**—For poisoning rats in buildings and
seminati occupied by poultry, the following method is recommended:
destruc wooden boxes should be used, one considerably larger than the
Int er, and each having two or more holes in the sides large enough
su to admit rats. The poisoned bait should be placed on the bottom
and near the middle of the larger box, and the smaller box should
then be inverted over it. Rats thus have free access to the bait, but
fowls are excluded.

TRAPPING.

Trapping, if persistently followed, is one of the most effective methods of destroying rats. The improved modern traps with a wire fall released by a baited trigger and driven by a coiled spring have marked advantages over the old forms, and many of them may be used at the same time. These traps, sometimes called guillotine traps, are of many designs, but the more simply constructed are to be preferred. Probably those made entirely of metal are the best, as they are less likely to absorb and retain odors.

In illustration of the effectiveness of traps, it may be related that a year or two ago a large department store in Washington experienced heavy losses of gloves, lace curtains, and other merchandise from rat depredations. For several months the damages amounted to from $10 to $30 nightly. After many unsuccessful attempts to abate the nuisance the managers were advised to try the improved traps. As a result 136 rats were killed during the first twenty nights, when the losses practically ceased, and the method has been continued in the store ever since with satisfactory results.

Guillotine traps should be baited with small pieces of Vienna sausage (Wienerwurst) or bacon. The trigger wire should be bent the straw and brush are thrown out over the top while dogs and men kill the trapped rodents. Large numbers are killed in this way, and the plan with modifications may be utilized in America with satisfactory results. A wire netting of fine mesh may be used for the inclosure. The scheme is applicable at the removal of grain, straw, or hay stacks, as well as brush piles.

FUMIGATION.

Rats may be destroyed in their burrows in the fields, and, still more important, in levees and rice-field dikes, by the use of carbon bisulphid. A wad of cotton or other absorbent material is saturated with the liquid and pushed into the burrow, the opening being packed with soil to prevent escape of the gas. All animals in the burrow are asphyxiated. Fumigation about buildings is not so effective, as the gas can not readily be confined.

RAT-PROOF CONSTRUCTION.

The best way of excluding rats from buildings, whether in the city or country, is by the use of cement in construction. As the advantages of this material are coming to be generally understood, its use is rapidly extending to all kinds of building. Dwellings, dairies, barns, stables, chicken houses, ice houses, bridges, dams, silos, tanks, cisterns, root-cellars, hotbeds, sidewalks, and curbs are now often made wholly of concrete. In constructing dwelling houses the additional cost of making the foundations rat-proof is slight as compared with the advantages. The cellar walls should have concrete footings and the walls themselves be laid in cement mortar. The cellar floor should be of " medium " rather than " lean " concrete, and all water and drain pipes should be surrounded with concrete. Even an old cellar may be made rat-proof at comparatively small expense. Rat holes may be permanently closed by a mixture of cement, sand, and broken glass or sharp bits of stone.

Rat-proof granaries, corncribs, and poultry houses may be constructed by a liberal use of concrete in the foundations and floors.

Rats, mice, and sparrows may be excluded from corncribs by the use of either an inner or an outer covering of fine-mesh wire netting sufficiently heavy to resist the teeth of rats.

The common custom of setting corncribs upon posts with inverted pans at the top often fails because the posts are not long enough to insure that the lower cracks of the structure are beyond jumping reach of rats. The posts should project at least 3 feet above the surface of the ground.

NATURAL ENEMIES OF RATS.

The value of carnivorous mammals and the larger birds of prey in destroying rats should be more fully recognized, especially by the farmer and the game preserver. Chief among the animals that are useful in destroying these rodents are the fox, skunk, and weasel, and the larger species of owls and hawks. Rats destroy more poultry and game, both eggs and young chicks, than all the birds and wild mammals named combined, yet some of our most useful birds of prey and carnivorous mammals are persecuted almost to the point of extinction. An enlightened public sentiment should cause the repeal of all bounties on these animals and afford protection to the majority of them.

CONCLUSIONS.

By the persistent use of traps, occasional resort to poison, and the exercise of forethought in the construction of farm buildings so as to minimize the opportunities for harborage, farmers and others may prevent the greater part of the loss and annoyance they now experience from rat depredations. The same statement applies in great measure to city and village conditions. Hence cooperation in the warfare on rats is particularly important and can not be too strongly urged.

O

1004 Issued July 12, 1907.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 298.

FOOD VALUE OF CORN AND CORN PRODUCTS.

BY

CHARLES D. WOODS, D. Sc.,
Director Maine Agricultural Experiment Station.

Prepared under the supervision of the Office of Experiment Stations.
A. C. TRUE, Director.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., May 6, 1907.

Sir: Believing that it constitutes a useful summary of data on the subject, I have the honor to transmit herewith and recommend for publication as a Farmers' Bulletin a report on the uses of corn and corn products as food, by Charles D. Woods, director of the Maine Agricultural Experiment Station, who has long been associated with the Office of Experiment Stations in its cooperative nutrition investigations.

Studies of the nutritive value of corn and corn products, particularly those carried on at the Maine and Minnesota experiment stations and at Teachers' College, Columbia University, have formed an important part of the cooperative nutrition investigations of this Office.

The special questions studied have included the digestibility of different sorts of corn bread and other corn-meal dishes, the digestibility of hominy, corn breakfast foods and green corn, the relative nutritive value of corn meal ground in different ways, and the culinary qualities and methods of manipulating old-fashioned and modern corn meal in order to secure uniform results. The data summarized from these investigations, from miscellaneous bulletins and reports of the agricultural experiment stations, and other sources, make it plain that corn meal is one of the most important food cereals when judged by its composition, digestibility, wholesomeness, palatability, and relative economy as a source of nutritive material.

Acknowledgment should be made to Miss Helen W. Atwater for assistance in compiling and arranging the data presented.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.

Introduction 5

Food value of corn 8

    Structure and composition 8

Milling 11

Cooking 15

Hulled corn 21

Corn breakfast foods 21

Pop corn and parched corn 22

Digestibility of foods made from corn 23

Wholesomeness of corn 26

Raw corn as an article of diet 28

Place of corn in the diet 29

Pecuniary economy of corn 32

Green corn 34

Summary 37

ILLUSTRATIONS.

Page.

FIG. 1. Diagrammatic section of a grain of corn 8

2. Cellular structure of a grain of corn 9

298

CORN AND CORN PRODUCTS AS FOOD.

INTRODUCTION.

The tall vigorous cereal plant known as maize, or Indian corn, is a native of the Western Hemisphere, and has been cultivated throughout the warmer regions of the Americas for twenty centuries or more. It has been claimed often that it is also indigenous to the Old World, but there is no warrant for this belief, though it has been grown in parts of Europe in which the climate is particularly favorable ever since Columbus brought the seed from the West Indies. It has also long been grown by the Arabs of northern and the Kafirs of southern Africa, and is a staple crop throughout vast regions of the African continent, as well as of southern and central Asia, China, and Australia. To attain its best development, corn needs both warmth and abundant sunshine, and so the climate of the northern regions of Europe is unsuited to its cultivation and it is there grown mainly for forage, any grain that reaches maturity being inferior in quality and little esteemed for human food.

Following the potato famine of 1847, an effort was made to introduce Indian corn into Ireland, and it has since been considerably eaten there, principally in the form of porridge, or "stirabout;" otherwise it can hardly be ranked as an important foodstuff in Great Britain, except, perhaps, in the dietaries of some of the public institutions, where it replaces more expensive cereals. In the Mediterranean and Balkan regions, however, where conditions are more favorable, its easy cultivation and abundant yield have made it one of the principal food crops. It has been estimated that Indian corn, or Turkish corn, as it is quite commonly known in Italy, forms the main food for two-thirds of the rural population of that country.

Its importance in America may be gathered from its name. Whereas in English-speaking regions of Africa it is known as mealies, and in Europe as maize, a name said to be derived from that originally used in the West Indies, in America it has usurped the name corn, which in Great Britain still refers to any grain regardless of kind. The fact that we sometimes modify this to Indian corn is, of course, a recognition of its origin.

The prevalent opinion is that corn was native to Central America and Mexico, and that it passed through the same stages of cultivation and dissemination which other important food plants have known. The Maya tribes, the relics of whose civilization are very old, cultivated corn, and it appears as the symbol of religion and prosperity in their art just as do other cereals in the early art of the Eastern Hemisphere. From the Mayas its cultivation spread throughout northern and western South America, the West Indies, and a great part of North America, and traces of corn have been found in the prehistoric mounds of Ohio, in the cliff dwellings of the Southwest, and in Peruvian mummy pits.

The grain kept from decay and destruction by the great dryness of many of these prehistoric burial places differs little, if at all, from varieties grown to-day. The stories often repeated of the raising of plants from such corn, or from the grain found in Egyptian tombs, are without foundation, as the life of the germ is not prolonged indefinitely, even under favorable conditions, though the chemical nature of the grain may remain practically unchanged.

By the time European travelers penetrated into the New World, corn was cultivated by all but the most northern and western tribes of North American Indians. When Cartier ascended the St. Lawrence he found fields of it where Montreal stands to-day. Hariot, in his account of the Virginia Colony, published in 1588, writes of maize as follows: "The graine is about the bignesse of our ordinary English peaze, and not much different in forme and shape, but of divers colours; some white, some red, some yellow, and some blew. All of them yeelde a very white sweete flowre; being used according to his kind, it maketh a very goode bread."

The early chronicles of Virginia contain many descriptions of the cultivation of corn, beans, pumpkins, and other plants by the Indians; and in very early times in the Jamestown colony Indian prisoners were forced to teach the English settlers how to plant and till this grain. An early chronicle of the Plymouth settlement told how, in the dreadful winter of 1620–21, the colonists bought "eight hogsheads of corne and beanes" from their Indian neighbors, and in the following spring learned from a friendly red man "bothe ye manner how to set it and after how to dress and tend it." For a time it was the principal breadstuff in the American colonies. Little by little, however, as wheat and other cereals became acclimatized these supplanted it among the well to do, though it has never passed entirely out of use in any section of the United States, and in some districts, particularly in the South and Southwest, it is still a staple cereal grain.

According to the census of 1900, almost a third of all the land under cultivation in the United States was devoted to corn. It was grown on 88.6 per cent of all the farms in the country, and the crop for 1889 was valued at $828,258,326. Wheat, the next most important crop, occupied only 18.1 per cent of the cultivated land, and was valued at $369,573,528. Of course these figures do not represent the relative importance of the two grains as human food, for while practically all the wheat is used in that way, either at home or in those countries to which it is exported, the greater part of the corn crop is used for feeding stock or as raw material in several important manufacturing industries. A better idea of its importance as human food may be gained from a recent compilation of American dietary studies made with many families in different parts of the country. Among 72 families in comfortable circumstances corn preparations furnished on an average 1.6 per cent of the total food; among 161 families, mostly foreigners in the congested districts of large cities, only 0.3 per cent; among Tennessee and Georgia mountaineers, 23 per cent, and among southern negroes 32.5 per cent. These figures refer only to the meals, flours, and similar preparations made from the ripe dried grains.

While meal, hominy, and similar products are the principal corn foods, there are a number of others of much importance. The unripe ears, especially of certain sweet varieties, are a favorite vegetable on American tables, and pop corn is a typical American food product of which the total amount consumed is very large. The roasted kernels of ordinary corn are sometimes used as a substitute for coffee, and apparently form a part of some of the mixtures commonly sold as coffee substitutes. Starch, glucose, gluten, and oil are also made from corn; and these and other important corn products will be discussed in later sections.

From an agricultural standpoint, corn is of the utmost importance, and this might be known, if for no other reason, from the fact that there is, perhaps, not one of the agricultural experiment stations, established in every State and Territory, which has not studied some phase of the corn question, either methods of cultivation, improvement of varieties, composition, feeding value for farm animals, or importance as a food for man. The State departments of agriculture and like organizations have also carried on much work of a similar nature. The importance of corn as an article of diet has been taken up especially at the Maine and the Minnesota experiment stations. The Department of Agriculture, and particularly the Bureau of Chemistry,[a] have also been large and important contributors to our knowledge of the composition and uses of corn and corn products.

As regards the preparation of corn for the table the literature is very considerable, almost every cookbook and journal of cookery containing recipes for corn dishes, while several such books are devoted exclusively to corn and corn products.

---

[a] U. S. Dept. Agr., Bureau of Chemistry Bul. 13, pt. 9, and Bul. 50; The food value of maize, etc., in Report on the Use of Maize (Indian corn) in Europe (U. S. Dept. Agr., Spec. Rpt. 1891).

FOOD VALUE OF CORN.

The food value of corn and its products, as compared with each other and with other food materials, of course depends mainly on the amount of nutritive materials or nutrients which the digestive organs can extract for the use of the body. Besides the water found in all food materials, even those which are apparently perfectly dry, the actual nutrients are grouped in four classes: (1) Protein or nitrogenous material; (2) fat; (3) carbohydrates, including starches, sugars, and the very indigestible constituents known as crude fiber or cellulose; and (4) mineral matters or ash. The two functions of the food are to furnish material for the building up and repair of body tissue and to supply energy for muscular work and body heat. Protein, fats, and carbohydrates alike can yield energy, but since only protein can serve for the necessary tissue building, this is usually considered its main function and the fats and carbohydrates are relied on to furnish most of the energy. All the changes which corn or other food undergoes in being prepared for eating are intended mainly to add to its palatability and get it into a form in which the nutrients can be most easily and completely utilized by the body.

STRUCTURE AND COMPOSITION.

Although the stalk and leaves are important cattle feeds, only the kernels of corn are ordinarily used for human food. They grow in double rows along a woody cob, from which they are easily shelled when ripe. The color of the skin may be white, yellow, red, purplish blue, or a combination of these, according to variety. They are all either white or yellow inside and differ little on an average save in color. The kernel or seed, it must be remembered, is not inert, but a living thing, which under favorable conditions will develop into a new plant, and each part of it is made up of cells especially fitted for a particular rôle in this process of reproduction. Roughly speaking, the seed consists of three main divisions: The skin, the germ, and the endosperm (see fig. 1). The skin, which makes about 6 per cent of the weight of the seed, holds the whole together and protects the delicate interior parts. It is made up principally of tough cellulose or crude fiber with some mineral matters

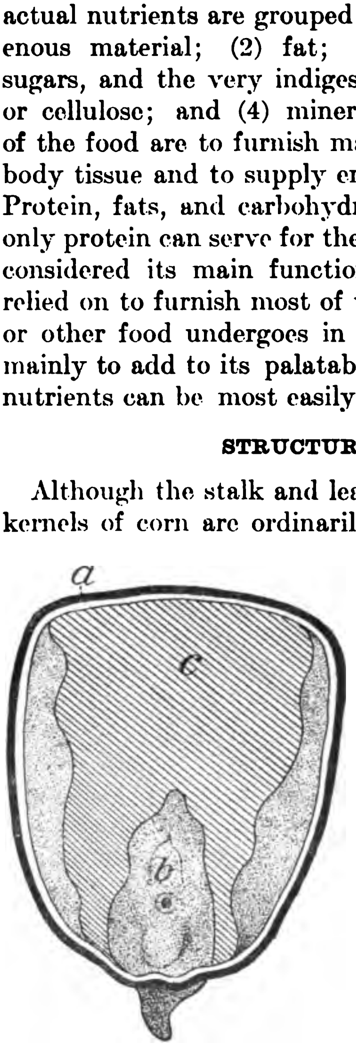


FIG. 1.—Diagrammatic section of a grain of corn: *a*, skin; *b*, germ; *c*, endosperm.

embedded in it. The germ is larger in corn than in most cereals, and forms in average corn about 10 per cent by weight of the grain, whereas in wheat it is only 6 or 7 per cent. It contains the embryo from which the new plant will develop under favorable conditions. The endosperm constitutes about 84 per cent by weight of the grain, and represents the food which the parent plant has stored for the early growth of the new plant. In the germ and endosperm, the cellulose walls of the cells are very much thinner than in the skin, and surround a network of nitrogenous material called protoplasm in which the life of each cell seems to reside. The food materials which the plant has stored for future use lie in the meshes of this protoplasmic network, together with some moisture; in the germ much of the stored material is fat and mineral matters. In the outer layers of the endosperm (see fig. 2), there are stored grains of a protein substance known as aleurone, and in the inner portions are found quantities of tiny starch grains with small amounts of protein and mineral matter. Table 1, taken from analyses made at the New Jersey Agricultural Experiment Station, shows how these constituents are distributed throughout the grain, the data being expressed on a water-free basis.

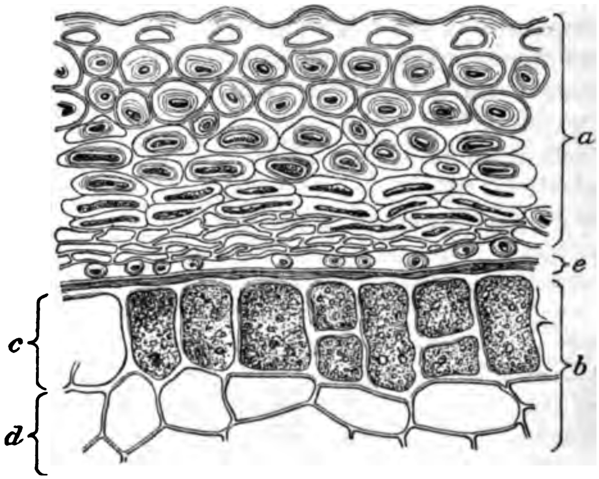


FIG. 2.—Cellular structure of a grain of corn: *a*, skin; *b*, endosperm consisting of (*c*) aleurone cells and (*d*) starch cells; *e*, membrane.

TABLE 1.—*Composition of different portions of a grain of corn.*

Portion of corn kernel.	Proportion in original grain.	Water.	In water-free material.				
			Protein.	Fat.	Total carbohydrates.		Mineral matters.
					Starch, sugar, etc.	Crude fiber.	
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Whole kernel	100.0	24.7	12.7	4.3	79.3	2.0	1.7
Skin	5.6	15.3	6.6	1.6	74.1	16.4	1.3
Germ	10.2	29.6	21.7	29.6	44.7	2.9	1.1
Endosperm	84.2	24.7	12.2	1.5	85.0	.6	.7

From these figures it may be calculated that 51 per cent of the cellulose of the grain is found in the skin, 65 per cent of the fat and about 16 per cent of the protein in the germ, 90 per cent of the starch and 84 per cent of the protein in the endosperm.

Grain of any kind is hygroscopic—i. e., has the power of absorbing water from the air—and the amount of moisture in it varies according to the climate and other conditions under which it is grown and stored. The proportion of nutrients in different varieties of the same species also differs considerably, being influenced by the selection of seed, the method of cultivation, the season, and other factors. The figures in the following table were prepared from many analyses and represent the average composition of the whole grains of corn and other common American cereals as ordinarily found in the market.

TABLE 2.—*Average composition of cereal grains.*

Kind of cereal.	Water.	Protein.	Fat.	Total carbohydrates.		Mineral matters.	Fuel value per pound.
				Starch, sugar, etc.	Crude fiber.		
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Calories.*
Indian corn	10.8	10.0	4.3	71.7	1.7	1.5	1,800
Barley	10.9	11.0	2.3	69.5	3.8	2.5	1,735
Buckwheat	12.6	10.0	2.2	64.5	8.7	2.0	1,600
Kafir corn	12.5	10.9	2.9	70.5	1.9	1.3	1,630
Oats	11.0	11.8	5.0	59.7	9.5	3.0	1,720
Rice	12.0	8.0	2.0	76.0	1.0	1.0	1,720
Rye	10.5	12.2	1.5	71.8	2.1	1.9	1,740
Wheat	10.6	12.2	1.7	71.3	2.4	1.8	1,750

As far as these figures show, the average water content of these cereals is almost the same, ranging from 10 to 12 per cent. Corn on an average contains 10 per cent protein, which is about 2 per cent less than the average rye or wheat contains, but 2 per cent more than the average rice. Its fat amounts to 4.3 per cent, or about the same proportion as is found in oats and over twice as much as in most of the other grains. In the proportion of starch they contain, corn, wheat, and rye are practically the same, and surpass all the other common grains except rice. The cellulose content of corn is smaller than that of any of the other cereals except rice, and it also contains a comparatively small proportion of mineral matters.

Though the proportions of the several nutrients in corn and other common cereals are much the same, the individual compounds[a] making up these groups differ considerably. As shown by extended studies at the Connecticut State Station, zein is the typical proteid of maize, and it differs in its properties considerably from the gluten of wheat or the proteids of other cereal grains. The fat of corn has a different chemical composition from that of wheat or other grains, and the ash also is characteristic.

---

[a] For discussion of the properties of corn proteids, see Connecticut State Sta. Rpts. 1891, p. 136; 1896, p. 391. Data regarding fat are summarized in Ann. Rpt. Ohio Dairy and Food Comr., 21 (1906), p. 18, and of carbohydrates in U. S. Dept. Agr. Bureau of Chemistry Bul. 13, pt. 9.

There is known to be some variation in the number and kind of starches, sugars, cellulose, and other bodies included under the heading "Carbohydrates," which occur in corn and other cereals, but it is generally believed that the bodies like starch which occur in the different plants have the same percentage composition. In size, appearance, the distribution of the concentric layers making up the granule, the readiness with which the starch absorbs water and is acted upon by ferments, and in other properties, starch grains occurring in different cereals exhibit considerable variations. The starch granules of corn resemble those of oats somewhat in appearance, but are larger.

Fat, when burned in the body, gives off 2.25 times as much heat as carbohydrates and protein, and corn, which contains relatively large proportions of both fat and carbohydrates, has a comparatively high fuel or energy value. The points in which the chemical composition of corn is superior to the other common cereals, then, are its richness in fat and starch and its small content of crude fiber. Its deficiencies lie in the small quantities of protein and mineral matters. The quality of its protein is less desirable for bread making than that of wheat and rye, as will be discussed later (see p. 17).

MILLING.

Occasionally whole grains of corn are used for human food, as in parched corn, pop corn, etc., but as a rule it is found preferable to break them up more or less before cooking. The Indians ground corn between two flat stones or pounded it, sometimes parching it beforehand. Another simple method, employed by the pioneer settlers, was to grate the newly ripened ears on a coarse grater, and many persons still maintain that in this way the best flavor of the grain is obtained.

Before the development of railways and elaborate milling machinery each community had its mill, usually by a stream, and here all the grain of the neighborhood was ground. The corn was simply crushed between the grooved millstones to the desired fineness. If the meal was intended for human food, the coarse particles of skin or bran were usually bolted out, though this was often done at home instead of at the mill. Nowadays cereals of all sorts are shipped from many districts to central mills in which complicated machinery grinds the grain much more carefully than was possible fifty years ago, and although the milling of corn is not as elaborate as that of wheat, it is no longer a simple process of crushing. To begin with, the grain is usually kiln dried (see p. 28), a process which hinders decay by lessening the vitality of molds and decay-producing bacteria, if they are present, and by driving off the water, without which such minute forms of life can not grow. Drying the grain also makes the skin separate more readily from the grain, and its removal before grinding is an advantage, since the skin consists largely of indigestible cellulose, which renders the meal coarse and rough without adding much to the food value. The germ lowers the keeping quality of the meal because its abundant fat easily becomes rancid, and now it is usually removed before the grain is ground. A machine known as the "degerminator" loosens both skin and germ, which are then easily bolted out, and the remaining endosperm is ground alone and bolted and purified by means of air currents. The offal removed consists of the hull, germ, floury particles, and some of the flinty portion of the corn, and constitutes 30 to 35 per cent of the entire weight of the grain. Meal from such degerminated grain is commonly called "granulated corn meal" and has almost replaced the old-fashioned kind for human food in the North, although the latter is still very popular in the Southern States. Both kinds are made in varying degrees of fineness. Very finely ground and bolted corn meal is known as corn flour, and is made from both yellow and white corn.

While meal is the form in which corn is best used for bread making, the less finely ground products, such as hominy and samp, are often preferred for porridge. The use of these terms is very uncertain and confusing. In colonial days in New England, samp designated the kernels of freshly harvested corn, but this use has now disappeared. In some parts of the country, the kernels which have been simply crushed sufficiently to loosen the hulls are known as samp, and those which have been crushed into bits not much larger than mustard seeds are called hominy, but in other sections the names are exactly reversed, while in many regions all such corn preparations are called hominy. The germ and skin are now usually removed in preparing these products, and their chemical composition is not, therefore, the same as that of the original grain. How this varies may be seen from Table 3, which gives analyses of corn prepared in different ways. The corn meals, both bolted and unbolted, were simply crushed, while the granular meals, hominy and samp, were "degerminated" before grinding.

TABLE 3.—*Average composition of corn products and wheat flour.*

Kind of material.	Water.	Protein.	Fat.	Carbohydrates. Starch, sugar, etc.	Carbohydrates. Crude fiber.	Mineral matters.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Corn, whole grain, average	10.8	10.0	4.3	71.7	1.7	1.5
Corn with low protein content	10.5	6.0	3.8	78.5		1.2
Corn with high protein content	10.5	12.9	4.4	70.8		1.4
Corn, white	11.4	10.8	5.0	68.8	2.5	1.5
Corn, yellow	11.9	10.7	4.8	68.9	2.2	1.5
Sweet corn (matured)	8.8	11.6	8.1	66.8	2.8	1.9
Pop corn	10.7	11.2	5.2	69.6	1.8	1.5
Hominy, fine	11.0	9.4	.7	78.2	.4	.3
Samp, coarse	10.8	8.3	.5	79.4	.7	.3
Corn meal (whole grain ground), unbolted	12.0	8.7	4.7	71.1	2.2	1.3
Corn meal (whole grain ground), bolted	12.0	8.9	4.9	72.0	1.2	1.0
Corn meal, granulated	12.5	9.2	1.9	74.4	1.0	1.0
Corn flour, i. e., finely ground and bolted corn	12.6	7.1	1.3	77.5	.9	.6
Corn starch	....	....	....	90.0	....	....
Liquid glucose (for table use)	16.0	....	....	83.5	....	.5
Corn oil	....	....	100.0	....	....	....
Wheat flour	11.1	11.4	1.3	75.5	.1	.6

The values given in the table for corn of low and of high p content show that there may be a considerable range in th portions of the different nutrients present. Such variation due to cultural varieties, to methods of cultivation, seed sele and other similar factors, and are noted in corn of all types. influence of different factors on the protein content has been st at the Illinois, Minnesota, Kansas, and other agricultural e ment stations with the object of breeding varieties of corn are especially rich in nitrogenous constituents, and this wor been attended with considerable success.

As the average figures show there is no appreciable differe the composition of white and yellow corn, the variations have been noted being smaller than are found in different a of either sort. When samples of the same grain are com whole corn and the unbolted meal made from it have the composition, as the process of grinding neither takes from no to the nutritive material present. The small variations be the whole corn and unbolted meal shown in the table are due fact that the figures are the average of many analyses of dif samples. When the corn meal is bolted, about one-eighth original grain is removed, this material consisting chiefly c cellulose of the skin. The removal of this material of increases the proportion of the other materials present, and i way it may be seen that the bolted corn meal is richer tha unbolted in nutrients other than crude fiber. Hominy, sam granulated corn meals resemble each other in composition, differences as those indicated in the table being no greater might be expected in a number of individual samples of either food material. In the manufacture of these corn products, the skin and germ have been removed and with them most of the crude fiber and considerable of the fat and mineral matter of the original grain. It might seem that in thus removing the fat and ash the food value would be decreased. This is only true in a measure, for it must be remembered that the proportion of carbohydrates, which are valuable nutrients and have the same functions as fat in nutrition, is increased. If a person lived exclusively on corn meal, the loss of the mineral matters might be serious, for a certain amount is necessary for the proper nourishment of the body. However, there is every reason to believe that the ordinary mixed diet contains a sufficient amount of the different ash constituents.

From the manufacturer's standpoint the removal of the germ does not represent a loss, as it is used for the manufacture of gluten feeds—so important for live stock—and corn oil, which has many industrial uses and is utilized to some extent as a salad oil and as a culinary fat. Cooking tests made in the home economics department of the Ohio State University showed that products in which corn oil was used as part of the shortening were of excellent quality, flavor, and appearance. Culinary fats are on the market which are claimed to be corn products, and studies carried on at the Connecticut State Experiment Station show that they contain corn oil as their characteristic constituent, the oil being stiffened with a harder fat.

The fine corn flour sometimes seen in American markets is granulated corn meal ground to the finest powder. What is called corn flour in England is known in the United States as cornstarch, and is the practically pure starch separated from the endosperm by special processes. It is commonly used for thickening puddings, sauces, etc., and in other ways, and has practically replaced arrowroot and the fine-grained tropical starches in invalid cookery.

The liquid glucose known as confectioners' glucose, or sometimes as mixing glucose, is a thick colorless liquid when well made, and is prepared in large quantities by inverting cornstarch, usually by boiling it with dilute hydrochloric acid and refining and evaporating the product. The liquid glucose sold for table purposes is often flavored with caramel or other materials and frequently contains added cane sugar.

Starch sugar or solid glucose is made in much the same way as the liquid product except that the treatment with acid is continued until practically all the starch is inverted. Although the liquid glucose and the starch sugar are not as sweet as cane sirup and cane sugar, they are considered to be perfectly wholesome, when well made, and of definite food value.

These glucose products made from corn are much used in the manufacture of certain forms of confectionery, being better adapted for certain kinds than cane sugar as they do not so readily harden and crystallize. The manufacture and use of liquid glucose and starch sugar have been spoken of in earlier publications of the Department.[a]

As is shown by the figures in Table 3, wheat flour of average composition is richer in protein than old-fashioned corn meal and contains about the same proportion of starch and less fat, crude fiber, and ash. In composition granulated corn meal differs from wheat flour mainly in containing less protein and more starch. Generally speaking, it will be seen that corn products compare favorably as regards nutritive value with such a standard food product as wheat flour.

COOKING.

Cooking cereals improves them in many ways. If bacteria or molds have found their way accidentally into the raw grain they are destroyed or rendered harmless by the action of heat. Although they knew nothing of micro-organisms, the American Indians and many other primitive people usually parched their grain before storing it, and in this way sterilized it as satisfactorily for their purposes as do modern millers by kiln drying. Cooking develops palatable flavors in foods. In the case of cereals and other foods rich in carbohydrates, the flavors are doubtless due in large part to the browning or caramelization of these constituents. Cooking also changes the mechanical condition of grain foods so that they may be more conveniently eaten and more readily acted upon by the digestive juices.

Parching is one of the simplest methods of cooking grains, and also doubtless the method first adopted by primitive man. Simple parched corn, it is said, is still eaten in central Asia and is regarded as a very convenient form of food for travelers in that part of the world.

Some of the desirable changes which heat produces in grain are most satisfactorily brought about when water is present, and from time immemorial it has been customary to mix grain with water or milk when preparing it for human food. The indigestible fiber of the cell walls breaks down under the combined action of moisture and heat, and so the real nutritive materials of the grain are more accessible to the action of the digestive juices than would otherwise be the case, for mastication, even if long continued, does not break down the cell walls of raw grain as easily or completely as is the case after cooking. Under the action of the moist heat the starch grains expand or swell and become soft and more porous, while a greater or smaller proportion of the starch may undergo what is known to the chemists as hydrolysis and be transformed from a substance insoluble in water to others which are readily dissolved. When there is no water present, as in parching, or when the water is very largely removed, as in baking or roasting, the starch tends to turn brown in color and acquires a pleasant toasted taste. In this process dextrin is formed, and as a whole these changes are akin to those noted in the caramelization of sugar.

---

[a] U. S. Dept. Agr. Yearbook, 1905, p. 241; Farmers' Bul. 93.

Little is known regarding the changes which take place in the protein and fat during the cooking of corn, but they are doubtless much the same as with other foods, protein being coagulated by heat and fat broken down to some extent into simpler bodies if the heat is intense or long continued. The amount of water which corn meal and other corn products require in cooking varies considerably, the fine meal, for instance, absorbing less water than the coarse.

The proportion of water in a cooked dish is obviously determined by the amount of liquid originally present or added in preparation and the amount evaporated by the heat of cooking. Catherine A. Williams [a] studied the amount of water absorbed by a number of cereal foods and found that 100 grams of hominy sprinkled into boiling water, cooked until soft, and then drained, weighed 623 grams, or in other words had absorbed 523 grams of water. The original material contained 13 per cent water and the cooked 87 per cent. When 100 grams of a cornstarch preparation was cooked with water 618 grams of thick porridge or blanc-mange was obtained with a water content of 87 per cent as compared with 13 per cent in the original material used.

Corn meal is cooked in a great variety of ways, but most of the dishes fall under two general heads, namely, bread prepared by baking, and porridge or puddings made by boiling. In the case of the ready-to-eat corn breakfast foods the cooking has been done at the factory; the preparation at the factory usually consists in rolling or flaking and sometimes parching and flavoring the thoroughly steamed or boiled and softened grain.

The composition of corn breads and corn porridge and other cooked corn products is shown in Table 4 in comparison with uncooked corn meal and wheat bread. The flavor, food value, and other characteristics of the corn foods are taken up in the sections which follow the table.

---

[a] Jour. Amer. Chem. Soc., 29 (1907), p. 574.

TABLE 4.—*Composition of cooked corn preparations, corn meal, and wheat bread.*

Kind of material.	Water.	Protein.	Fat.	Carbohydrates.		Mineral matters.	Fuel value per pound.
				Starch, sugar, etc.	Crude fiber.		
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Calories.*
Hominy, boiled	79.3	2.2	0.2	17.8		0.5	380
Hoecake	52.8	4.0	.6	40.0	0.2	2.4	885
Johnnycake	29.4	7.8	2.2	57.5	.2	2.9	1,385
Boston brown bread	43.9	6.3	2.1	45.7	.1	1.9	1,110
Corn breakfast foods, flaked, (partially cooked at factory)	10.3	9.6	1.1	77.9	.4	.7	1,680
Corn breakfast foods, flaked and parched (ready to eat)	7.3	10.1	1.8	77.2	1.2	2.4	1,735
Indian pudding	60.7	5.5	4.8	27.5		1.5	815
Cornstarch blanc-mange (made with cornstarch and water)	87.3	2.9	.1	9.5	....	.2	230
Parched corn	5.2	11.5	8.4	72.3		2.6	1,915
Popped corn	4.3	10.7	5.0	77.3	1.4	1.3	1,880
Hulled corn	74.1	2.3	.9	22.2		.5	490
Granulated corn meal	12.5	9.2	1.9	74.4	1.0	1.0	1,655
Wheat bread	35.3	9.2	1.3	52.6	.5	1.1	1,205

As has been stated, granulated corn meal and ordinary wheat flour are not very different in chemical composition, and the corn is often cheaper in price; nevertheless, wheat ranks far ahead of corn as a breadstuff, perhaps the most important reason for this being that wheat yields a lighter and more porous loaf with yeast or other leavening agent. This is due to the character of its protein, which consists largely of a substance known as gluten, so elastic in its nature that it stretches the dough into little pockets as the gases from the yeast expand within it. The heat of cooking hardens the gluten and so the finished loaf retains its porous structure. The only cereal which compares with wheat in the elastic and tenacious qualities of its nitrogenous constituents is rye. Corn contains no such gluten, and even when mixed with equal amounts of rye or wheat flour and raised with yeast, as in the old-fashioned "rye and Indian" bread, it does not give anything like as porous a loaf as either wheat or rye alone.

For the most part, therefore, corn breads are of the unleavened or flat bread type and are granular rather than porous. They are usually baked in thin loaves or cakes, and so the lack of gluten is less important. They do not keep as fresh as yeast-raised breads and should be eaten soon after baking. The simplest kind of corn bread is that in which the meal is mixed with water or milk and baked. Such were the cakes which the American Indians baked in the ashes of their camp fires or on a heated stone; such are the tortillas of Spanish America and the hoecakes of our Southern States (which get their name from the fact that the cake is sometimes baked on the blade of a hoe held over the coals), and the ash cakes or corndodgers, which, wrapped in a cabbage leaf, are baked in the hot ashes of the fireplace. Johnnycake and corn bread, popular in New England and other parts of the country, used to be prepared in much the same way, and were baked on a board before the fire and in later times in the oven; but nowadays they are usually made with part corn meal and part wheat flour and slightly raised by the addition of baking powder, eggs, etc. Other corn breads and cakes are made by mixing eggs, sugar, sour milk and baking soda, butter, lard, or other materials with the meal. Sometimes white and sometimes yellow meal is used in these preparations, each sort having its advocates who maintain that it is much superior to the other. As a matter of fact, analysis has shown that there is no constant difference in the composition of the two sorts of meal, and it seems equally certain that there is no uniform difference in flavor or cooking quality.

The famous Boston brown bread was originally a mixture of rye and Indian meal sweetened with molasses and lightened a little by the gases evolved by mixing sour milk and soda. It was made into large, thick loaves, which required long, slow cooking, such as was best obtained in the old-fashioned brick ovens. The weight of the loaves was fixed by law in Massachusetts in colonial times, and bakers were required to stamp their initials on the bread. Nowadays Boston brown bread is usually made with corn meal, rye, and whole-wheat flour, and is cooked by steam in small loaves in tightly covered tins. Combined with beans it has long been the orthodox Saturday-night supper or Sunday breakfast in many parts of New England. Such brown bread canned in small tins is a common commercial product. It is probably made like any other "Boston brown bread" except that it is cooked and sterilized in the sealed cans.

A sweet cake something like gingerbread is sometimes made by mixing molasses and spice into a johnnycake batter, and is an old-fashioned favorite in many homes. Projaca is a Servian corn bread in which eggs and cheese are mixed with maize meal, the dough covered with leaves and baked either in pans or in the ashes, somewhat like the ash cakes of our Southern States.

In Italy a considerable effort has been made to substitute maize wholly or in part for the more expensive wheat in making macaroni and other similar pastes. These foods, it should be remembered, which are used in the United States as an occasional substitute for vegetables and in similar ways, in Italy are eaten in large quantities as a staple food by all classes and often form the main if not the whole of a poor man's meal. Their advantage over flour, aside from their compactness, is that they are less liable to become moldy or to be attacked by insect enemies and may be easily and quickly prepared for the table with only the simplest cooking conveniences. While wheat is much better adapted to making these pastes, owing to its tenacious gluten, such goods made of mixtures of wheat and maize or of maize alone are by no means unpalatable. Their use, however, is certainly not common, and their manufacture, which attracted considerable attention in Italy not long ago, seems never to have assumed much commercial importance.

Practical cooks differ in opinion regarding the relative values of the old-fashioned bolted and the new granulated corn meals in bread making. There is certainly a difference in flavor, due to the removal of the germ in grinding the granulated meals, but whether the distinctive flavor thus acquired is an improvement or not is largely a matter of individual opinion, and undoubtedly a person usually likes the sort to which he has been accustomed.

As to the texture of bread, the difficulty experienced with the newer types of meals often arises from the fact that recipes intended for the old-fashioned sorts are used without modification. Because they contain less fat the granulated meals require more shortening material than those which include the germ. They also absorb water less readily than the old-fashioned sorts, and for this reason some cooks prefer to scald the granulated meal before mixing it with the other ingredients. An extended series of tests carried on at Teachers' College, New York, as a part of the nutrition investigations of the Office of Experiment Stations, has shown that, when properly manipulated, bread from granulated corn meal is fully as light as that made from plain bolted meal, and that under such conditions the difference in texture and quality of the breads and other products from the two types of meal are not particularly marked.

The early colonial records tell us that the Indians pounded corn, often previously parched, to a coarse meal and made a sort of mush from it. Sometimes nuts, berries, beans, pumpkins, etc., formed part of the dish, while sometimes meat or fish were used much as the Scotch mix meat with oatmeal in their meat brose. It is not surprising that the colonists took kindly to corn-meal porridge, as it was similar to the dishes made from other cereals which they had known at home.

"Hasty pudding," or corn-meal mush, which may be made with either milk or water, is a dish which can be quickly cooked, as its name implies, though long slow cooking is generally conceded to yield a better dish. Good cooks always insist that the water must be vigorously boiling and that the meal must be slowly stirred in, a little at a time, in order that the mush may be smooth and of the proper consistency. Hominy and samp, which are much coarser than meal, require longer cooking, and for this reason are often considered less convenient than other similar cereals. The very coarse hominy is not an economical dish where cooking is done on a gas stove and fire must be kept especially for it, but in households where the range is hot all day a dish of it in a double boiler at the back of the stove will almost cook itself. Sufficient water is important in cooking hominy and samp, as the grain, if not constantly covered with water, becomes rather hard and dry. On the other hand, too much water makes the dish gummy and unattractive. To be properly cooked each grain of hominy, though soft, should retain its distinct form, as is the case with well-cooked rice. Old-fashioned meal and hominy made from corn which includes the germ have a more distinctive flavor than the products made from degerminated grain, and for this reason they are often preferred for porridge making, though the use of one sort or the other is, of course, entirely a matter of taste. A New England cookbook of one hundred years ago gives the following advice: "For Sunday morning in winter fry the hasty pudding that was left over from Saturday night's supper. Eat it with West India molasses or Muscovado sugar." Fried mush and fried hominy are still favorite breakfast dishes. They are also sometimes served with meat in the place of vegetables, as is also plain boiled hominy.

Corn-meal mush is so much used under the name of polenta in many parts of Italy that it may almost be called the national dish. Polenta is made much like hasty pudding, except that some grated cheese or lard or other fat is commonly one of its ingredients. With poorer people polenta often constitutes the bulk of the daily fare, while in more well-to-do families it is an accompaniment of meat dishes and other foods, and is served in a variety of ways, many of them worthy of a trial by American housekeepers.

Tamales, a Mexican corn-meal dish formerly little known to American cooks except in the southwestern United States, are now comparatively common. In making these, corn meal suitably prepared is mixed with meat or chicken and chili peppers or other seasoning, wrapped in corn husks and boiled until well cooked. So well known has this dish become that canned tamales are on the market.

Indian pudding, a favorite family dessert in this country, is made by mixing molasses, butter, spices, etc., with corn meal into a batter with milk or water. It used frequently to be boiled in a cloth like Christmas plum pudding, but now is more commonly baked or steamed in a deep dish.

Many cooks use corn starch for thickening sauces, etc., because it gives them a smoother consistency than flour. It also forms the basis of puddings, in which it is mixed with milk, sugar, eggs, etc. Such dishes are very nutritious and palatable, and are believed to be easily digested, which accounts for their use in invalid cookery.

Corn-meal gruel, a palatable dish once much more commonly prepared for invalids than at the present day, is cooked for such a long

time and with such large proportions of water that the crude
of the corn meal is quite completely broken down and the st
very largely converted into a smooth, almost jelly-like condition

Though the proportion of water may be higher in mush or porı
than in corn bread, yet such foods are nutritious and may be rea
combined with other dishes to form a palatable and wholesome

HULLED CORN.

Hulled corn, or lye hominy, is prepared by steeping the kerne
hot water which contains lye, or sometimes simply a small ba
wood ashes, until the hulls are loosened or softened. The coı
then soaked in plain water until the lye is washed out and
boiled until it is soft. When it is eaten in milk as a breakfast
or used in other ways, its distinctive flavor makes it a food much l
in many families. One hundred years ago it was a common cus
for housewives to prepare hulled corn for the use of their fam
but the process is time-consuming, and it is now commonly purch
from dealers, who often make a specialty of supplying it. Lye hoı
is a common product in Washington and Baltimore markets,
the hulled corn vender is well known in many New England t
and elsewhere in the northern United States. A number of br
of canned hulled corn are on the market which differ in no appreci
degree from the freshly prepared product. As the figures in Tal
show, hulled corn has much the same composition as boiled hon
It owes its distinctive flavor in considerable measure to the t
ment with lye.

CORN BREAKFAST FOODS.

There is at the present time a great number of proprietary bı
fast foods on the market, some of which are ready to eat, while ot
need only a little cooking, and so are easier to prepare for the t
than the old-fashioned meals or grits made from similar grains
number of these breakfast foods are made from corn. In the ca
the partially cooked and ready to eat brands the processes of m
facture are apparently the same as with similar foods made from c
grains. Selected grain, carefully freed from all impurities, is stea
or cooked until it is soft, then flaked or rolled by passing it thr
heavy rollers, and dried. Sometimes the flakes are parched wit
without the addition of malt. Variations in the process of manı
ture give the granular preparations and other varieties with whic
are all familiar. Corn breakfast foods, like other goods of this t
are very commonly marketed in packages. The food value of t
corn preparations and other breakfast foods has been discussed i

earlier bulletin of this series.[a] In general it may be said they are comparatively concentrated foods, as they contain little water, and are quite similar to corn meal in chemical composition.

POP CORN AND PARCHED CORN.

Special varieties of corn with hard, small kernels are used for popping. Pop corn was formerly sold on the ear, but now it can be bought already shelled, in bulk, or packed in small cardboard boxes. Such corn has been carefully kiln-dried and perhaps pops more evenly than the home-dried product. In the popping, which takes place when the kernels are exposed to intense heat like that from a good bed of coals, the endosperm expands and pops or bursts white and crisp through the torn skin. It was formerly supposed that this bursting was due to the sudden expansion of the fat in the grain, but it is now known that it is caused by the sudden expansion of the cell moisture into steam. In pop corn the cell walls are very firm and hard and do not burst until the pressure is quite considerable. Ordinary varieties of corn, in which the cell walls are softer, when treated in the same way, expand and sometimes burst more or less, but do not have the characteristic popped appearance.

During popping, corn loses considerable water, and so it contains a larger proportion of nutrients than the original grain. Chemical changes take place also in the nutrients themselves, though they are not very well understood. Part of the carbohydrates are undoubtedly browned or caramelized, and it is believed that the peculiar flavor of popped corn is due in a measure at least to this fact. It is a matter of common experience that the flavor and texture of popped corn deteriorates if it is kept for any considerable time after popping. Apparently the loss of crispness is due to the fact that the freshly popped corn is so very dry and porous that it readily absorbs moisture from the air.

Popped corn is usually eaten out of hand and can hardly be called an important food product, though the total amount used in the United States is large—about 300 carloads annually, it has been estimated. Puddings and other foods are sometimes made from popped corn, and popped corn and milk is an old-fashioned dish which is wholesome and may be made to accord with modern habits by using it as a breakfast cereal. Popped corn is, however, most commonly eaten with salt and butter or made into a sort of confectionery with molasses or sugar.

Popped corn resembles other corn products in composition, except that it contains less moisture. Its very porous structure makes it a comparatively bulky food. So far as can be learned, its digestibility has not been studied experimentally, but there is no reason to supp that it is not easily and thoroughly digested.

---

[a] U. S. Dept. Agr., Farmers' Bul. 249.

It is often stated that pop corn is used in large quantities in t manufacture of breakfast foods and for the adulteration of flour, b both these statements are denied on good authority.

Parched corn, made from ordinary varieties which expand b do not burst on heating, is eaten to a limited extent out of ha As the figures in Table 4 indicate, it does not differ very mate ally in composition from popped corn.

Infusions of parched corn or of "browned" corn meal or parch brown bread crusts are old-fashioned coffee substitutes which ma persons consider among the most palatable cereal coffees. The fo value of "corn coffee," like that of all similar beverages, depends ve largely upon the sugar and cream added to it, for the small quant of caramel or other browned material which it contains in solutio not of much importance, and 99 per cent of the infusion is water.[a]

DIGESTIBILITY OF FOODS MADE FROM CORN.

The real value of any food material depends not only on the amou of nutrients which it supplies but also on the proportion of these nu ents which the digestive organs can convert into such a form that th may be absorbed into the blood and made available for the nouri ment of the body—in a word, upon digestibility. The thorough of digestion of the more common food products has been carefu determined. A number of digestion experiments have been m with corn, the first of these being perhaps that reported by Rub about thirty years ago. He found that a man on a diet of corn-m porridge, with a little butter, meat extract, and cheese, retained in body 85 per cent of the protein, 83 per cent of the fat, 97 per cen the carbohydrates, and 70 per cent of the ash which the food suppl Somewhat later Malfatti, an Italian, studied the digestibility of ma porridge (polenta) eaten with cheese and found that 93 per cent of protein, 91 per cent of the fat, 98 per cent of the carbohydrates, a 81 per cent of the ash were digested. Somewhat lower values found when the polenta was eaten without the cheese. In m recent Italian experiments with polenta, much the same results w obtained, though the values found for protein were rather lov Macaroni and similar pastes made wholly or in part of corn m though somewhat more digestible than the corn-meal mush w found to be a little less digestible than similar foods made from whe

Harcourt[b] at the Ontario Agricultural College and Experimen Farm studied the digestibility of a number of breakfast foods, incl ing corn-meal mush. According to his experiments, 74 per cent of the protein and 99 per cent of the carbohydrates of corn-meal mush are digested when it forms a part of a simple mixed diet.

---

[a] See also U. S. Dept. Agr., Farmers' Bul. 249, p. 33.

[b] Jour. Soc. Chem. Indus., 26 (1907), p. 240.

The digestibility of corn-meal mush or "hasty pudding" and boiled hominy has also been studied recently at the Maine Experiment Station. The hasty pudding was made by stirring meal into salted water and cooking it in a double boiler. It was found that in the case of a mixed diet containing considerable quantities of hasty pudding 89 per cent of the total protein and 99 per cent of the carbohydrates were digested, while 97 per cent of the energy of the diet was available for the body. When the hasty pudding was eaten with a little milk or sugar and constituted a considerably larger proportion of the diet, 82 per cent of the protein and 99 per cent of the carbohydrates were digested and the quantity of energy available was the same as before. The calculated values for the digestibility of hasty pudding alone were: Protein 73 per cent, carbohydrates 98 per cent, and available energy 93 per cent. The experiments of similar nature which were made gave for hominy as a part of a mixed diet, for hominy with milk and sugar, and for hominy alone practically the same values as were obtained for the mush. From all the experimental data the conclusion may be fairly drawn that the nutritive ingredients of dishes made by cooking corn in water are well assimilated.

The digestibility of corn breakfast foods has been studied at a number of the experiment stations, particularly in connection with the cooperative nutrition investigations of the Office of Experiment Stations. As has been pointed out in an earlier bulletin of this series,[a] which discusses the digestibility and nutritive value of cereal breakfast foods as a whole, 74 per cent of the protein, 90 per cent of the fat, and 99 per cent of the carbohydrates of corn breakfast foods are assimilated, while 95 per cent of the energy is available. These values, it will be seen, are very similar to those given above for corn-meal mush, etc.

An extended series of experiments on the digestibility of corn bread of different sorts, including hoecake, johnnycake, and Boston brown bread, was also carried on at the Maine Experiment Station. In every case the same sort of granulated corn meal was used. The brown bread was made of equal parts of corn meal and wheat flour mixed with milk, molasses, baking powder, and a little salt. It was steamed in cans for four hours. The johnnycake was made of equal parts of corn meal and wheat flour, with suitable quantities of milk, sugar, baking powder, and salt. Neither flour nor baking powder was used in the preparation of hoecake. The meal was stirred into boiling water until a thick pudding was formed, which was immediately spread in thin sheets upon hot well-greased iron plates and baked at once. For purposes of comparison, digestion experiments were also made with wheat-flour bread. The foods under consideration were eaten with milk and sugar, or sirup in the case of hoecake—this ration being termed a simple diet—and as a part of a more elaborate mixed ration which also included canned peaches and meat.

---

[a] U. S. Dept. Agr., Farmers' Bul. 249.

The average figures which were obtained for the different corn-bread rations with the healthy young men who served as subjects and the calculated values for the bread alone are shown in Table 5, which also contains, for purposes of comparison, the results of the similar study with wheat bread made from standard patent flour.

TABLE 5. *Average digestibility of corn bread of different sorts compared with wheat bread.*

Kind of food.	Entire ration.			Corn products alone.		
	Protein.	Carbohydrates.	Heat of combustion of digested material.	Protein.	Carbohydrates.	Heat of combustion of digested m[illegible]
	Per cent.	*Per cent.*	*Per cent.*	*Per cen[illegible]*		
Hoecake in mixed diet	90.0	98.8	92.6			
Hoecake in simple diet	87.0	98.7				
Hoecake with sirup	84.4	99.[illegible]				
Johnnycake in mixed diet	90.1					
Johnnycake in simple diet	89.[illegible]					
Boston brown bread in mixed diet						
Boston brown bread in simple diet						
Wheat bread in mixed diet						
Wheat bread in simple diet						

in-
sensation of
its protein content is
y cause an appreciable increase
body as compared with wheat or other
ying the different classes of nutrients in
and carbohydrates and so is a fattening food, as
The data in the n the feeding of farm animals abundantly demon-
total diet, inclu known to protect the body from extremes of tempera-
of the corn pro may be that corn has been spoken of as a heating food,
very favorab valuable in the winter diet, on account of its fat-producing
carbohydra her than because of any specific heat-producing properties.
body. Th n "heating foods" seems often to mean simply hearty foods;
ucts, indi hose which because of their bulk, the length of time they
ence upon the stomach, or for other reasons delay the normal recur-
digested hunger for a longer time than usual. Some corn dishes,
protei orn-meal cakes with sirup, or the crackling bread of southern
wh ks which contains the pork cracklings or scraps left after lard is
tho dered, are unquestionably hearty foods, but no more so than
to milar dishes made from other cereals. Certainly simple corn breads
of nd other simple corn dishes do not seem to particularly merit this designation.

In this connection it is interesting to note that corn has always been a more important foodstuff in the southern United States, Mexico, and the Mediterranean regions than in corresponding northern regions, even where it is a common market commodity, and this would certainly indicate that there can be no reason for supposing the total diets and that the protein of the total simple diets is less thoroughly digested than that of the mixed diets. These facts are in accord with observations in many similar experiments, and are believed to indicate that the digestibility of protein depends somewhat upon the proportion of protein to other nutrients in the diet. The Italian experiments in which the protein of cheese—a material rich in protein—and corn porridge were more thoroughly digested than that of corn porridge alone or with butter, strengthen this belief.

All the above-mentioned tests referred to thoroughness of digestion, and give no information with respect to the ease or comfort with which food is assimilated. The time which elapses between the eating of food and the excretion of the undigested residue of it does not vary much with the ordinary foods, and the rapidity of digestion therefore usually has reference to the length of time which food remains in the stomach. Although to a healthy person this is probably a matter of little moment, it may be a question of considerable importance with were'ids. Unfortunately it is very difficult to obtain definite infor-
energy 93 perh matters. Beaumont, in his famous observations on
made gave for hominy with a gunshot wound in his stomach, found
and sugar, and for hominy alonstomach three hours and fifteen min-
obtained for the mush. From all tihours and thirty minutes. In
clusion may be fairly drawn that the nutrembered that starch, the
made by cooking corn in water are well assimila intestines rather than

The digestibility of corn breakfast foods hasbservations as Beau-
number of the experiment stations, particularly here are differences
the cooperative nutrition investigations of the Office fairly claimed,
Stations. As has been pointed out in an earlier bgested without
series,[a] which discusses the digestibility and nutritive v
breakfast foods as a whole, 74 per cent of the protein, 90
the fat, and 99 per cent of the carbohydrates of corn brea
are assimilated, while 95 per cent of the energy is availabl rn on the
values, it will be seen, are very similar to those given above tible and
meal mush, etc. eals in

An extended series of experiments on the digestibility o erm bread of different sorts, including hoecake, johnnycake, and Boston brown bread, was also carried on at the Maine Experiment Station. In every case the same sort of granulated corn meal was used. The brown bread was made of equal parts of corn meal and wheat flour mixed with milk, molasses, baking powder, and a little salt. It was steamed in cans for four hours. The johnnycake was made of equal parts of corn meal and wheat flour, with suitable quantities of milk, sugar, baking powder, and salt. Neither flour nor baking powder was used in the preparation of hoecake. The meal was stirred into boiling water until a thick pudding was formed, which was immediately spread in thin sheets upon hot well-greased iron plates and in most cases will doutbless make up for any differences in e thoroughness of digestion.

---

[a] U. S. Dept. Agr., Farmers' Bul. 249.

The digestibility of any ordinary cereal food is increased by the cooking, as this tends to break down the crude fiber of the cel and changes the physical or chemical nature of the starch so t is more readily acted upon by the digestive juices. The more ce a food contains the more important it is that the cooking sho thoroughly done, and so the desirability of properly cooking cor is obvious.

Corn is frequently spoken of as a good winter food, but "heating" or "heating to the blood" for summer. Just what expressions mean is not easy to say. Carefully conducted e ments have shown that as a rule the consumption and digest carbohydrates and fats does not materially increase the output body heat, but that protein does cause an increase in the amoun ated or otherwise given off by the body. Generally speaking, ho in the few experiments which have been made with man t creased liberation of heat has not been accompanied by a sensat warmth. Corn is not a typical proteid food, as its protein cont not over 10 per cent, so it would hardly cause an appreciable in in the output of heat from the body as compared with wheat or common foods also supplying the different classes of nutrie reasonable proportion.

Corn is rich in fat and carbohydrates and so is a fattening fo its extended use in the feeding of farm animals abundantly d strates. Fat is known to protect the body from extremes of ten ture and so it may be that corn has been spoken of as a heating particularly valuable in the winter diet, on account of its fat-pro qualities rather than because of any specific heat-producing prop

The term "heating foods" seems often to mean simply hearty that is, those which because of their bulk, the length of ti remain in the stomach, or for other reasons delay the normal rence of hunger for a longer time than usual. Some corn like corn-meal cakes with sirup, or the crackling bread of so cooks which contains the pork cracklings or scraps left after rendered, are unquestionably hearty foods, but no more so similar dishes made from other cereals. Certainly simple corn and other simple corn dishes do not seem to particularly mer designation.

In this connection it is interesting to note that corn has been a more important foodstuff in the southern United Mexico, and the Mediterranean regions than in corresponding no regions, even where it is a common market commodity, an would certainly indicate that there can be no reason for sup that cold weather is more appropriate for the use of corn foods than warm. The most reasonable deduction from available data is that the way in which corn dishes are prepared and cooked, and the foods with which they are combined are more important factors than climate in regulating the use of these foods, and that, rightly used, corn bread and other corn dishes are wholesome at all seasons.

A curious and often fatal disease, which has at times been very prevalent in Italy and the Balkans, was formerly believed to be due to the large quantities of maize eaten by the poor of these regions. This disease, which in Italy is called pellagra, begins with eruptions on the skin and in later stages is attended by serious intestinal and cerebral disturbances, and often terminates fatally. Carefully conducted investigations have shown that this disease is not due to the maize itself, but to a mold or fungus which readily grows in the grain when it is stored in damp places, as is commonly the case in these regions, and which in its growth develops poisonous substances. Fortunately, this fungus has never infected corn in the United States, but the evils which attend such infection emphasize the need of taking adequate measures to prevent it and show the advantages of thoroughly sterilizing the grain, as by kiln-drying, before it is used by either man or animals, for when once started such an infection is very difficult to check.

The occasional digestive disturbances which are noted after eating corn and corn products are of the same sort as occur with other foods, and may be due to overindulgence, to some personal idiosyncrasy, or some similar cause, and may be left out of account in considering the general question of the wholesomeness of this grain. That it is wholesome and well suited to its numerous uses as a food product is abundantly proved by its long-continued use under a great variety of circumstances and conditions and the high opinion in which it has always been held. Scientific investigations have abundantly justified the popular conclusions on the subject.

RAW CORN AS AN ARTICLE OF DIET.

Any extended study of questions concerned with the selection and use of foods shows that such topics have received much attention since earliest times, and that many widely divergent and contradictory theories have been proposed. One of the theories which has again attracted attention is that cooking decreases the value of food. Regarding corn and other cereals, the upholders of this theory say that not only is the healthy body able to digest them raw but also that the heat of cooking greatly decreases their nutritive value by destroying the "vital principle" of the grain. Exactly what this "vital principle" is or what effect it has on the body is not explained.

Indeed, aside from the possible value in some cases of the ferments present in the raw food, there is no experimental evidence to support the theory nor does physiological chemistry give any ground for believing it. Persons of healthy digestion can undoubtedly eat raw cereals in reasonable amounts with impunity, provided the materials are thoroughly masticated and are free from accidental contamination from dangerous micro-organisms, which often accompany dust and dirt and are conveyors of disease. Raw starch is digested in the body, but it is much more difficult to break down the cell walls protecting the starch in raw grains than it is when they have been cooked.

In cases of constipation the quantity of crude fiber and the coarse, mechanical condition of this raw corn and other similar cereal products may sometimes have a beneficial effect, but judged by composition and digestibility they can certainly possess no advantage over the cooked foods. To forego the advantages produced by cooking seems to involve a useless waste of digestive energy for persons of delicate digestion, if not for all.

PLACE OF CORN IN THE DIET.

According to commonly accepted dietary standards, the daily food of a man doing light to moderate muscular work should provide about 0.23 pound of protein for the building and repair of his body tissues and other uses and 3,000 calories of energy for his bodily activities. Of course, as muscular work increases or decreases, these quantities, particularly the energy, should be correspondingly increased or decreased. Women on an average are smaller in stature than men and so require relatively less food, as do also children. The ideal diet is one which supplies the right quantities of nutrients in the proper proportion and in an appetizing and attractive form, while at the same time it is reasonable in cost.

About 3 pounds of corn meal would furnish the protein called for by the above-mentioned standard, but would supply with it about 4,830 calories of energy or more than one and one-half times as much as is required. If, on the other hand, the amount should be so reduced that only the desired energy is supplied, the protein furnished would be only about two-thirds of the assumed requirements. Thus, it is evident that corn contains too little protein in proportion to its energy-yielding constituents to be a well-balanced food when used alone. Even if it furnished the proper proportions of protein and energy, corn would hardly be an ideal food for use as the sole article of diet, for it would be very bulky, 3 pounds of corn meal, when cooked into bread or mush, representing a rather formidable amount of food. Moreover, corn, or, indeed, any other single food, would not long seem appetizing to a person accustomed to a varied diet, and it is an accepted physiological fact that appetizing qualities have much to do with stimulating the activity of the digestive organs. The fact that, under stress of need, people have lived for considerable periods on corn alone does not prove that such a diet is to be recommended, but rather that the body has great powers of adapting itself to an emergency. In the United States it has always been the custom to combine corn with other foods rich in protein, as such combinations as mush and milk, Boston brown bread and baked beans, and hominy and fried chicken testify, and these combinations are more rational than either food used alone. The Italians often mix cheese with corn in making polenta or mush, and thus increase the protein content, as well as vary the flavor of the dish. Milk, which contains considerable protein, is also commonly used with corn meal by the peasants of southern Italy; and, indeed, it may be said to be a general rule with corn as with other carbohydrate foods that the attempt is universally made to provide by proper food combinations the protein which the body seems to demand.

Among the negroes and mountain whites of the southeastern United States large quantities of corn are used in combination with salt pork, sirup or molasses, milk, some wheat flour, and more or less green vegetables and fruit. The common designation "hog and hominy" points out the leading features of this diet and suggests its faults. Salt pork, which consists almost wholly of fat, adds very materially to the energy value of the diet without adding much of any protein, and none of the other foods supply enough of this constituent to make the diet well balanced. Among 70 families in the mountain regions of eastern Tennessee the average diet yielded 0.18 pound of protein and 3,600 calories of energy per man per day, which is 77 per cent of the protein and one-fifth more than the energy suggested by the dietary standard referred to above (see p. 29). In this diet, which was cooked and served in the simplest ways, corn supplied about 35 per cent of the protein and 30 per cent of the energy. Similar conditions were noted in the families of negroes in Alabama, and also studied in connection with the nutrition investigations of the Office of Experiment Stations. Taken as a whole, the people who live very largely on such a diet do not [illegible] physical condition, as well nourished, or as pro- [illegible] more fortunately situated. [illegible] lack of protein and too great a [illegible] how much to poor cooking, [illegible] living conditions it would [illegible] the Alabama studies, however, [illegible] general sources of information, [illegible] and more efficient work attend [illegible] When the corn was more [illegible] meat, cowpeas, and other legumes, and the foods were better prepared, a general improvement was noted in the Alabama families, as, indeed, it generally is when a better and more generous diet is made possible for a family or community long accustomed to opposite conditions.

With a mixed diet of meat, eggs, milk, vegetables, fruit, etc., such as is found in homes in the United States, the exact proportion of protein to energy in each individual food material is of less consequence than when the food consists of two or three materials only. If breakfast with its bread and cereal yields too little protein this will ordinarily be offset by dinner in which meat, custard, cheese, beans, lentils, or similar foods will probably be used. In such a diet as this, corn ordinarily is used in place of some other cereal which it approximates in composition, and the diet as a whole is usually well balanced.

One good feature about corn meal is that it can be made into an appetizing bread perhaps rather more easily and quickly than wheat flour. During the civil war large quantities were used by the soldiers of both armies and it was found that, although the meal did not keep as well as wheat flour, a palatable corn cake could be made from it under almost any conditions, whereas it required some considerable experience and skill to make even fairly edible wheat bread with the simple utensils which were oftentimes the only ones available. For the same reason campers and others who live for any length of time away from a base of supplies not infrequently prefer corn meal to wheat flour, especially when it has been thoroughly kiln-dried (see p. 12). It has been said that the name johnnycake is a corruption of journey cake, and that corn bread was so called because it could be so easily prepared on the road. In the ordinary household with its well-equipped pantry and kitchen this feature is not a matter of as much importance as it would be under other conditions, but even here corn bread may often help the housekeeper in an emergency more easily than could wheat biscuits.

Corn meal, when used for bread, cakes, porridge, puddings, etc., and hominy and other corn foods are cheap and apparently well-digested sources of both protein and energy, and although like other cereal foods, not well fitted to supply a suitable diet if used alone, these corn dishes combine readily with other materials to form a ration which is in accord with accepted dietary standards, and which is at the same time palatable and wholesome. The corn dishes which may be easily prepared are very numerous, and this important food-stuff might well be used more frequently than is at present the case in the average American home, to give an inexpensive variety to the diet as well as for its generally valuable qualities.

PECUNIARY ECONOMY OF CORN.

The relative economy of different food materials depends not merely on the price per pound but also on the amount of digestible nutrients which a given sum will purchase. Ten cents spent for potatoes will yield a much larger bulk of food, for instance, than the same sum spent for flour, but so great a proportion of potatoes is water, or juice, and inedible skin that the body actually obtains less than half as much protein and energy as from 10 cents' worth of wheat flour.

Table 6 compares corn and a number of other foods as sources of digestible protein and energy when valued at certain assumed average prices per pound.

TABLE 6.—*Cost of nutrients of corn and of other food materials at certain assumed prices.*

Kind of material.	Price per pound.	Cost of 1 pound of protein.	Cost of 1,000 calories of energy.	Amount for 10 cents.				
				Total food material.	Protein.	Fat	Carbo-hydrates	Energy.
	Cents.	*Dollars.*	*Dollars.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Calories.*
Corn meal, granulated...	2.5	0.32	0.02	4.00	0.31	0.07	2.96	6,540
Do...	3.0	.44	.02	3.33	.23	.06	2.48	5,534
Hominy...	4.0	.62	.02	2.50	.16	.01	1.97	4,178
Samp...	5.0	.78	.03	2.00	.13	.01	1.57	3,342
Corn breakfast food, flaked and parched...	13.0	1.73	.08	.77	.06	.01	.60	1,335
Wheat flour...	3.0	.31	.02	3.33	.32	.03	2.45	5,440
Wheat breakfast food...	7.5	.73	.04	1.33	.13	.02	.98	2,235
Wheat bread...	5.0	.64	.04	2.00	.16	.02	1.04	2,400
Oatmeal...	4.0	.29	.02	2.50	.34	.16	1.66	4,500
Beans, white, dried...	5.0	.29	.03	2.00	.35	.03	1.16	3,040
Corn, green, canned...	10.0	4.21	.23	1.00	.02	.01	.18	430
Potatoes, 60 cents per bushel...	1.0	.67	.03	10.00	.15	.01	1.40	2,950
Beef, sirloin...	20.0	1.28	.20	.50	.08	.08	....	515
Beef, shoulder clod...	9.0	.57	.13	1.11	.18	.10	....	795
Pork, roast, lean...	12.0	.92	.10	.83	.11	.19	....	1,035
Pork, salt, fat...	12.0	6.67	.03	.83	.02	.68	....	2,950
Butter...	25.0	25.00	.07	.40	....	.32	....	1,365
Cheese...	16.0	.64	.08	.63	.16	.20	.02	1,185
Milk, 7 cents per quart...	3.5	1.09	.11	2.85	.09	.11	.14	885

The first column of figures in the table shows the assumed price per pound, the second and third compare the foods at these assumed prices as sources of protein and energy, while the remaining columns show the amounts of nutrients and energy which 10 cents expended for the foods at the stated prices per pound would furnish.

Of the foods included, corn meal, oatmeal, and wheat flour, it will be seen, are the cheapest sources of protein with the exception of dried beans, and also of energy with the exception of potatoes and salt pork. Corn meal sells at a lower price than hominy or samp; and, as they all have practically the same composition and so furnish nearly the same amounts of protein and energy per pound, it is obvious that the meal is more economical than these products. The specially prepared corn breakfast foods included in the table are more than twice as expensive sources of protein and energy as hominy and still more expensive as compared with corn meal.

From this table it would appear that the low-priced whe in reality fully as cheap as corn meal, and this is undoubt when these foods are brought under ordinary market conc most parts of the country. In remote sections, however, su mountain districts of our southeastern States, where climate conditions are favorable to the production of corn, where mill ties are primitive and communication with other regions di requires a smaller outlay for a man to furnish his family than with wheat. In the dietary studies made among the mountaineers already referred to, 20 per cent of the total fo the form of corn and the total cost of the food per man per da from 3 cents to 16 cents, the average being 9 cents. In 2 made in an especially remote district of eastern Tennessee th cost was only 7 cents, and with these families corn was also t food. Whatever one may think regarding the ultimate phy and sociological value of such a diet, there can be no two regarding its immediate cheapness.

Throughout Europe more intensive cultivation is require the United States, and wheat commands relatively a mu price than corn where the latter is a market commodity. also a difference on the side of wheat in the United States, less than it was formerly, for during the last fifty years th corn has risen while that of wheat has decreased. Pereira writing as early as 1850, reported that a bushel, or about 60 p good corn could be bought for about 56 cents, and that a pou would yield from 2.5 to 3 pounds of food, so that "if an i could live on this alone his annual expense for food would or say $15 for a family of five." According to the dietary s previously referred to it would require nearly 3 pounds c furnish the necessary protein; but even so, a man in 1 had been possible for him to subsist on corn alone, wo expended but 3 cents a day, or $10.95 a year, and at presen prices for corn such a diet would cost about the same. Th lations are interesting as illustrations of the relation betwee and nutritive value of an important foodstuff, but, of cours imply that it would be possible or desirable for a person t corn or any other single foodstuff.

Food materials of nearly all kinds are more expensive i than in the United States, and the diet of many persons, pa those of limited means, are very much less generous or va than here. Rye bread and milk or cheese with some v

---

[a] Treatise on Food and Diet. New York, 1850, p. 161.

constitute the bulk of the food throughout large regions of northern Europe. Corn meal from the United States could be sold in these regions even more cheaply than the rye or other cereals so extensively used at present, and both the United States and the European governments have tried to introduce corn as a substitute for, or a supplement to, other cereals; but in spite of its cheapness the people have not taken to it any too kindly, in part, doubtless, because the home-grown corn with which they are familiar is of inferior quality, and in part because they are ignorant of the proper ways of preparing and cooking it and do not understand how to make from the corn dishes which are similar to those which they prepare from other grains. Such difficulties, however, should not be insurmountable, for the use of corn has become widespread in China and other parts of the East, and the differences in dietary habits which were overcome before this was possible must have been greater than those which exist between the Europeans in question and ourselves. It would be of mutual advantage to American producers and European consumers if such difficulties could be set aside, and it seems probable that eventually this will be accomplished.

GREEN CORN.

Green corn or sweet corn is commonly spoken of as a distinctively American dish, but this is not really the case, although the cultivation of certain varieties for use as green vegetables is much more common here than elsewhere. Green corn is little known in the northern and western parts of Europe, though it may be found, for instance, in the large London markets, and canned corn is obtainable in many European cities. In the Balkan regions, however, the unripe ears are roasted and considered a delicacy as with us. In his report for 1901 the commissary-general of the United States Army states that the American troops sent to the relief of Peking obtained green corn from the natives along the line of march and notes that the Chinese frequently cooked it on the cob, though they regard it more as a fruit than as a vegetable. In Africa and Australia, where corn is extensively grown, the unripe ears are used as food, though not as generally as in the United States and Canada. A recent publication[a] notes the extended use of both green and ripe corn by African natives who cultivate corn and a number of other food plants. The article further states that they are accustomed to chew the green succulent corn stalks, which are sweet, as they do sugar cane.

As everyone knows, the special varieties of corn which are characterized by a sweet taste are most prized for use as a vegetable, and analysis shows that these varieties actually contain considerably more sugar than corn raised for other purposes. Taking the average of a number of analyses, 5 per cent sugar and 15 per cent dextrose and other soluble carbohydrates have been reported in ripe sweet corn as compared with 3 per cent sugar and 3 per cent dextrose and other soluble carbohydrates in the varieties of corn commonly raised for feeding purposes and for manufacture into meal. The Massachusetts experiment station has reported 0.8 per cent cane sugar and 0.4 per cent glucose, making 1.2 per cent total sugar as the average amounts present in a large number of samples of sweet corn gathered when just ready for the table. Much higher values than these have been noted in individual samples.

---

[a] Jour. Trop. Med. London, 10 (1907), p. 157.

Corn on the cob is not very convenient to serve or eat and this method of cooking it would doubtless have been abandoned long ago if cutting the kernels from the cob before cooking did not materially modify the flavor. In household practice it is usually more convenient to boil the ears, but in old-fashioned fireplaces or at camp fires roasting is a deservedly popular method of cooking corn. Green corn, like other vegetables, is at its best when freshly gathered. It is commonly believed that corn which has been picked any considerable time is not as sweet as that which is freshly gathered. That this is actually the case was proven by recent investigations by the Bureau of Chemistry of this Department, which showed that sugar disappears from the kernels very rapidly after the ear is separated from the stalk, and within 24 hours after harvesting, if exposed to ordinary temperature, is almost entirely absent. The season of corn is more nearly limited to the season of maturity in a given region than tha of almost any other common vegetable, for it can not be stored for any considerable time in good condition, even with modern appliances, and corn grown in warm climates and shipped long distances to our winter markets is very expensive and rather uncertain as to it quality. Corn, however, may be readily canned on a commercia scale, and when this is properly done it retains many of its desirable qualities. It is not surprising, therefore, to find that canned corn is one of the most popular canned vegetables. In canning corn the process is much the same as that followed with other vegetables. The kernels cut from the cob and salted are sterilized in sealed cans, the aim being to apply the heat in such a way and for such a time that the micro-organisms causing decay will be destroyed, while at the same time the process is so regulated that the flavor and appearance are changed as little as possible. For a long time the attempts which were made to can corn on the cob were not very successful, but methods have been improved, and corn canned on the cob is becoming an important article of commerce.

Succotash, a mixture of unripe corn and beans cooked together, i a dish which was borrowed, name and all, from the Indians, and ha been a favorite since colonial times. To vary their winter diet, the colonists often cooked dry ripe corn and beans together, but such a dish does not possess the palatability of that made from green corn. Corn with tomatoes is another mixture which many persons like and which is quite commonly served. Canned corn with tomatoes is on sale, but is much less common than canned succotash or canned corn alone. Small immature ears of unripe corn are sometimes used in mixed pickles, particularly in Europe, and relishes are also made in the United States from green corn, both as a domestic article and commercially. The amount of green corn used for such purposes, however, is very small compared with that used fresh or canned.

Table 7, which follows, shows the composition of green corn, fresh and canned, succotash, and corn and tomatoes, and also includes for purposes of comparison similar data for some other common vegetables.

TABLE 7.—*Average composition of green corn and other vegetables.*

Kind of material.	Refuse.	Water.	Protein.	Fat.	Total carbohydrates.		Ash.	Fuel value per pound.
					Starch, sugar, etc.	Crude fiber.		
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Green corn on cob, as purchased	61.0	29.4	1.2	0.4	7.7		0.3	180
Green corn on cob, edible portion		75.4	3.1	1.1	19.2	0.5	.7	470
Green corn, canned		76.1	2.8	1.2	18.2	.8	.9	455
Green corn and tomatoes, canned		87.6	1.6	.4	9.1	.5	.8	225
Succotash, canned		75.9	3.6	1.0	17.7	.9	.9	455
Beans, Lima, fresh, as purchased	55.0	30.8	3.2	.3	9.1	.8	.8	255
Beans, Lima, fresh, edible portion		68.5	7.1	.7	20.3	1.7	1.7	570
Potatoes, as purchased	20.0	62.6	1.8	.1	14.7		.8	310
Potatoes, edible portion		78.3	2.2	.1	18.0	.4	1.0	385
Tomatoes, fresh		94.3	.9	.4	3.3	.6	.5	105

Young corn contains on an average a little more protein and starch and a little less sugar and cellulose than the mature grain, but differs chiefly from the dry ripe corn in containing much larger percentages of water. It furnishes about as much food material, pound for pound, as potatoes, but its nutritive value, as with all fresh vegetables, is low compared with that of such foods as dry ripe beans or the cereal grains. When purchased on the ear it includes over 60 per cent inedible portion or refuse, whereas the amount lost with the skin of potatoes is usually only 20 per cent. Considering the comparatively high price of green corn of good quality in the markets of large towns and cities, it is certainly a more expensive food than potatoes or some other vegetables. If grown in the home garden, however, such comparisons do not hold, and under any usual circumstances it is a reasonably economical vegetable when in season. Like most green vegetables it is more valued for its palatability and for the pleasant variety which it gives to the diet than for the nutrients which it supplies, and is certainly not expensive as compared with other foods of this class.

It is often stated that green corn is very indigestible. If the ears are not fresh and of good quality the corn may cause digestive disturbances, particularly if improperly cooked; and, as is the case with almost any other food, overindulgence may be followed by unpleasant consequences. When eaten from the cob green corn is often not thoroughly masticated and the kernels or the skin which covers them often pass through the body apparently unchanged. While of course this lessens the amount of nutritive material which the body obtains from the corn, there is no reason to suppose that this is harmful for a healthy person; but if desired the condition may be very largely avoided by running a knife lengthwise along the rows and splitting the skins of the kernels before they are eaten.

A digestion experiment made at Wesleyan University, Middletown, Conn., by Bryant and Milner, in connection with the nutrition investigations of the Office of Experiment Stations, showed that green corn when eaten in considerable quantity as a part of a simple mixed diet was fairly well assimilated, about 84 per cent of the protein and 97 per cent of the carbohydrates which it supplied being retained by the body, and on the whole it compared favorably with other vegetables which were studied at the same time. Such data are too limited for general deductions, but taken in connection with the almost universal experience that green corn when well cooked is a wholesome vegetable, they indicate that it does not deserve the reputation for "indigestibility" sometimes ascribed to it.

Succotash and corn and tomatoes are similar in composition to the vegetables of which they are composed, while canned corn has practically the same composition as the freshly cooked product.

Green corn, both fresh and canned, is often used for making soups, fritters, and other dishes, and in this way adds to the palatability and variety of the diet.

SUMMARY.

Although a native of the new world and first extensively cultivated there, Indian corn or maize is now grown very generally wherever the climate permits. In the United States corn is by far the most important cereal, and is grown in every State, though the southeastern and middle western sections are the great corn regions. The greater part of the corn crop is used for feeding live stock and poultry, or for starch making or other manufacturing purposes. Nevertheless, corn has always been and still is a favorite and very important source of human food in America, and especially in the South Atlantic States, where it ranks with wheat as a breadstuff.

The germ of corn makes up an unusually large percentage of the kernel as compared with most grains, and as the germ is very rich in fat the grain as a whole is characterized by an unusually large proportion of this constituent. The proportion of protein is also fairly high. Carbohydrates, particularly starch, make up the greater part of the nutritive material of corn, as of other cereals. Until about fifty years ago corn was simply ground and then bolted or sifted at the mill or at home in making meal for cookery, but now it is usually kiln-dried and deprived of the outer skin and germ before grinding. The modern granulated corn meal is bolted to free it from offal products and is finer and keeps better than the old-fashioned sort, though it does not differ from it very materially in composition except that it contains a little less fat and crude fiber. The removal of the corn oil modifies the flavor, though it undoubtedly improves the keeping qualities. In general, corn meal contains a little more fat and starch and a little less protein than wheat flour, but after all it resembles this staple foodstuff quite closely in chemical composition.

The changes brought about in corn by the heat of cooking are much the same as those observed in other cereal grains. Thus, the cell walls made up of indigestible crude fiber are softened and broken down and so the starch inside may be more readily reached by the digestive juices. Heat, with or without the presence of water, changes some of the insoluble starch into forms which are easily dissolved, a condition favorable for digestion. Cooking has further advantages in that it improves the flavor of corn and thoroughly sterilizes it, a matter which may be very important under some conditions.

Corn protein does not contain the elastic, tenacious gluten which is characteristic of wheat protein and so corn meal does not give a light porous loaf with yeast. For this reason corn meal alone is seldom used for raised bread, but is usually baked in thin cakes which are granular rather than porous, although such leavening material as eggs, sour milk with soda, etc., may be used in making the batter. When [illegible] mixed [illegible] wheat flour or rye flour the dough [illegible], of which "rye and Indian" [illegible]latable when slowly cooked in [illegible] used for making mush or [illegible]dding," this dish used to be [illegible]ently served as a supper [illegible]

[illegible]ely ground than corn [illegible]monly used as a break- [illegible]company meat. Hominy is now [illegible] germ. Like other similar [illegible] long-continued and thorough [illegible]

Hulled corn is an old-fashioned dish in which the kernels, instead of being ground or degerminated, are steeped in lye until the hulls are loosened, soaked in clear water until free from alkali, and then boiled until soft and tender.

There are various proprietary breakfast foods made from corn. In most of these the grain has been cooked until tender and then rolled or flaked and sometimes parched with or without the addition of malt or other flavoring material.

Small hard varieties of corn when shaken over a hot fire pop or burst to a white, light mass, owing to the sudden expansion to steam of moisture in the cells making up the interior of the grain. Popped corn is sometimes used at table, but is usually eaten out of hand. The total amount consumed is fairly large. Varieties of corn which will not pop are sometimes parched and eaten and are also used as a coffee substitute.

Cornstarch has long been an important foodstuff commonly used for making puddings and desserts and for invalid cookery. Glucose made from cornstarch is a very common commercial product. The use of corn oil as a culinary fat is comparatively recent but seems promising.

Corn meal and other corn products are used in making an endless variety of batter breads, cakes, and other dishes for which recipes may be found in books devoted to cookery.

Unripe or green corn is frequently used as a vegetable, particularly in America. Like all green vegetables it is succulent and contains a small amount of nutritive material in proportion to its bulk, being esteemed for its pleasing flavor and the variety which it gives to the diet rather than for its direct food value. Corn canned alone or mixed with beans or tomatoes is a common commercial product, reasonable in price, and a useful addition to the list of vegetables, particularly in the winter diet.

Careful experiments made to test the digestibility of corn indicate that the carbohydrates are almost completely utilized by the body no matter how the grain is cooked. The method of preparation, however, apparently makes considerable difference in the digestibility of the protein. Thin, porous corn bread, such as johnnycake, and even the thick loaves of Boston brown bread, made of equal parts of corn, rye, and wheat, furnish as large a proportion of digestible protein as white wheat bread raised with yeast. On the other hand, the protein of hoecake (corn meal mixed with water and baked in thin sheets) has been found to be slightly less digestible than that of wheat bread, while the protein of hasty pudding and boiled hominy is only about 73 per cent digestible as compared with 83 to 86 per cent in the above-mentioned types of corn bread.

The corn breakfast foods and other corn products have much the same digestibility as corn meal when cooked in similar ways. The variations which have been noted with the different corn breads and other corn dishes are of the same character as those observed with similar foods made from wheat flour of different sorts.

Corn, though a wholesome and very useful foodstuff which may be cooked in many ways, is not likely to replace wheat as a leading breadstuff where the latter can be obtained, as wheat bread is commonly considered to be more appetizing for everyday use and has an advantage in that it keeps for a longer time in good condition after baking. Corn breads, however, give a pleasant variety to the diet, and being more easily and quickly made than wheat bread are especially useful when hot bread is wanted and time is limited. Corn breads and corn cakes are so easily made that they are favorites in camps and wherever cooking appliances are few and simple.

Where conditions are especially favorable to corn cultivation, as in the mountain districts of the southeastern United States, some parts of Italy, and the Balkan regions of Europe, corn is often the staple cereal food and not infrequently the principal article of diet for the poor. In times of distress people have lived on this grain alone for considerable periods, but, like other grains, it contains too little protein in proportion to its fat and carbohydrates to supply the body with nutritive material in the proper proportion, and it should be combined with materials rich in protein, such as lean meat, milk, cheese, dry beans, etc. When thus combined it is a healthy, nutritious, and inexpensive food and has been proved by common experience to be wholesome, palatable, and a welcome addition to the diet.

Considering all of its uses, corn is one of the most important cereal foods from the standpoint of palatability, nutritive value, and digestibility. It may be prepared for the table in a great variety of ways, and in some form or other is deservedly used in the majority of American homes.

O

Issued June 18,

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 299.

DIVERSIFIED FARMING UNDER T PLANTATION SYSTEM.

BY

D. A. BRODIE,
Assistant Agriculturist,
AND
C. K. McCLELLAND,
Scientific Assistant, Farm Management Investigations,
Bureau of Plant Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., May 8, 1907.

SIR: I have the honor to transmit herewith a paper entitled "Diversified Farming under the Plantation System" and to recommend that it be published as a Farmers' Bulletin.

This paper was prepared, under the direction of the Agriculturist in Charge of the Farm Management Investigations of this Bureau, by Mr. D. A. Brodie and Mr. C. K. McClelland, who have conducted careful investigations on this subject for several years past.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

B. P. I.—289.

DIVERSIFIED FARMING UNDER THE PLAN TION SYSTEM.

INTRODUCTION.

At sundry times and at various places much of the farm lan this country has been devoted to the growing of one particular c If for a series of years a certain crop brings a high price, many far are likely to plant large areas of that crop, and often the entire is given over to it. Again, certain soils in certain climates themselves peculiarly to the best development of a certain crop, here also the entire acreage is likely to be in that particular crop

Without disputing the good points of such practice, such as profits secured at times, the possibility of establishing a reputatio a certain product, the thorough knowledge obtained of a partic crop and its peculiarities, and the small equipment of machi required for it, it is only necessary to point out some of the evil r of the system in order to convince most people of its harmfulnes

One result of the continued cultivation of a single crop is th fection of the soil with spores of fungous diseases peculiar to the p grown. The practice also results in a rapid depletion of soil ferti In unfavorable years—years of frost, of drought, of much rai insect attacks, or of very low prices—the farmers who depend one crop are brought to a realization of the value and the nec of diversification.

In the United States there have been many examples of this of diversification, and also many examples of the resulting evils. the Central States corn was grown for many years on the same until low prices and low yields compelled the farmers to diversify. the North and the Northwest wheat was, and in many places is almost the only crop grown. Many farmers who depended up alone went out of business during several successive unfavo periods. Similar results have been observed at various times cotton, sugar cane, rice, potatoes, hops, grapes, peaches, ap onions, and other crops. Just recently a disease has been f upon melons which may make it more profitable to grow some crop for a few years. There is also a root-rot appearing upon radishes which may necessitate the abandonment of that crop upon infected soils. So, also, the ravages of the boll weevil are compelling the southern farmer to diversify. If the boll weevil causes both the upland and the bottom-land farmers of the South to diversify and rotate their crops, it will prove to be not an unmixed evil.

Upland farmers take more readily to diversification and rotation than do the river-bottom planters, and for several reasons. In the first place their soils are poorer, and a rotation of crops is imperative in order to obtain any reasonable yield, while the bottom soils have such a mine of fertility in and beneath them that it is often many years before there is any noticeable decrease in yield, even where only one crop is grown. The average number of acres to the owner is less on the hill than on the bottom land and the tenants are fewer in number. The hill farmers usually live upon their farms, while the bottom-land planters as a rule reside in town, where it is impossible for them to keep an eye upon all the details of a diversified system of farming. Besides being in a position to better oversee the work, the hill farmers also do more of their own work, and this is an important factor in diversification. It can hardly be expected that a class of tenants whose crop of cotton often grows in spite of, rather than because of, them will make a success of live stock, truck, or fruit growing—complex industries which require a more thorough knowledge of scientific agriculture. After tenants have been instructed how to handle such products and have become accustomed to them there will be less difficulty in planning for diversification. The bottom-land planters usually keep only enough live stock to carry on the work of the plantation, while it is no uncommon thing to find a hill farm with twenty to thirty head of cattle, an equal number of swine, and several head of mule or horse colts. The keeping of live stock necessitates growing more forage crops; consequently more of the total acreage of the farm must be devoted to the raising of this feed. These forage crops are fed to the live stock, and the manure is returned to the soil, thus preserving its fertility.

The planters maintain that because of the roving tendency of the tenant class they can not plan for diversified farming. This roving is partly due to the desire of the tenant to better himself, each man wanting to work where he can make the most money. In the two examples cited later the planters say that to hold their tenants all they have to do is to show that the tenants can make more on that particular plantation than upon any other. The planters do this by encouraging their men to fix up their homes, so that they will be homes in the true sense of the word, to grow as much as possible upon their holdings of what they need to eat, to keep more or less live stock, and to raise forage for that stock. And then the planters advise them to grow such crops as will bring in money at various seasons of the year. It is no trouble to hold a tenant with such surroundings and with another pay day only a few weeks ahead, but it is very easy to lose one when there is only an annual pay day, as is the case when cotton is the only money crop.

One of the main reasons for this lack of diversification is the lack of forehandedness among the tenant class and the disinclination of the planters and the merchants to lend money or supplies on anything but cotton. This is because cotton is "tangible." A dishonest tenant can dispose of eggs, butter, grain, pork, hay, or truck without the knowledge of his creditor, but a cotton bale is too large to escape undetected, and especially so as the planter gets a record of it as it passes through the gin. Unfortunately, it is true that most of the merchants do not want to abolish the credit system. It is to their advantage to continue it, and some of them fail to see that the entire country is held back because of it.

Many of the planters affirm that there is no money in anything but cotton, but this has been proved a fallacy. At the present prices of pork and the cheapness of producing it in the South, and at the present prices of hay and other forage, of cowpeas for seed, of good cows, of truck, and of mules, money can be made in diversified farming.

The planters are held in a system fixed by their predecessors. This system was a development through a series of years of very peculiar conditions, a development in which few of the present planters played a part, but resulting in a system from which many of them do not care to depart and do not know how to depart. This paper is intended to show those who may desire to change their methods how other men have started in the work of diversification.

Mr. F. M. Greene, of Atlanta, Tex., instructs each of his tenants to devote a few acres each year to Irish potatoes, and then, by digging all at the same time, a carload is obtained for shipment. Later in the summer cabbages are planted on this land, to come off in January and February. This last winter (1906-7) a profit of $150 an acre was realized on the cabbage crop. This is a simple system of diversification, but it gives the men three money crops at three different times of the year.

AN EXPERIMENT IN DIVERSIFIED FARMING.

In 1906 the Louisiana Agricultural Experiment Station and the United States Department of Agriculture began some diversification work with the tenants on the Rosalie Plantation at Moreland, La., owned by Mr. William Polk, of Alexandria, La. Mr. Henry Easterbrook, of Pineville, La., had direct charge of this work, under the supervision of the Office of Farm Management Investigations of the Bureau of Plant Industry.

Each tenant set aside for this experiment nearly 2 acres of land, on which he planted potatoes, watermelons, sweet corn, and cabbage—approximately one-half acre of each. These crops were planted at the same time by all of the tenants, so as to be ready for harvest at the same time upon all of the fields.

Because of poor seed and excessive rainfall in the early spring the corn crop was very poor. In four instances it was a complete failure, while in the others there was an insufficient quantity for marketing, and it was therefore fed to stock upon the place. From May 6 until June 26, 1906, there was no rain, and because of this the cabbage crop was also a failure. One tenant, A. Palmer, planted sweet potatoes when the corn and cabbage failed. These yielded at the rate of 271 bushels to the acre. Half of the crop was sold at prices ranging from 50 cents to a dollar per bushel, the average price being 60 cents. The other half was kept for family use.

The Irish potato crop was decidedly a success, as shown by Table 1, only one tenant reporting a failure:

TABLE 1.—*Potato crop, 1906, of tenants on the plantation of William Polk, near Moreland, La.*

Serial No.	Name of tenant.	Area planted.	Yield of the plot.	Yield to the acre.	Gross receipts.	Expenses to the acre.					Net profit.	Loss.	Net profit to the acre.
						Fertilizers.	Seed.	Bags.	Rent.	Total.			
		Acres.	*Bush.*	*Bush.*									
1	H. Edwards	[illegible]	31	107 5/24	$27.90	$6.88	$6.88	$1.26	$0.73	$17.75	$12.15	......	$42.02
2	N. Dixon	[illegible]	40	106⅔	36.00	3.44	6.88	1.68	.94	12.94	23.06	......	61.49
3	J. Crawford	[illegible]	34½	103½	31.13	3.44	6.88	1.40	.84	12.56	18.57	......	55.71
4	J. Brown	[illegible]	47 7/10	95⅜	42.93	3.44	6.88	1.75	1.25	13.32	29.61	......	59.22
5	G. Mason	[illegible]	43⅛	86⅓	38.85	3.44	6.88	1.75	1.25	13.32	25.53	......	51.06
6	J. Chase	[illegible]	41 4/15	82½	37.14	3.44	6.88	1.68	1.25	13.25	23.89	......	47.78
7	T. Grimble	[illegible]	36⅛	72⅓	32.55	3.44	6.88	1.40	1.25	12.97	19.58	......	39.16
8	A. Figgins	[illegible]	31 7/12	71 11/60	28.43	3.44	6.88	1.33	.94	12.59	15.84	......	41.24
9	W. Odom	[illegible]	34⅝	69⅜	31.35	3.44	6.88	1.47	1.25	13.04	18.31	......	36.62
0	I. Carey	[illegible]	31⅓	63	28.35	3.44	6.88	1.33	1.25	12.90	15.45	......	30.90
1	T. Jefferson	[illegible]	30¼	68	27.83	4.13	6.88	1.19	1.13	13.33	14.50	......	32.63
2	I. Thomp	[illegible]	28 7/12	57⅙	25.73	3.44	6.88	1.26	1.25	12.83	12.90	......	25.80
3	Willia	[illegible]	28¼	56½	25.43	4.13	6.88	1.33	1.25	13.59	11.84	......	23.68
4	oodm	[illegible]	26⅔	53⅓	24.00	3.44	6.88	1.12	1.25	12.69	11.31	......	22.62
5	one	[illegible]	25 5/12	50⅝	23.03	3.44	6.88	1.05	1.25	12.62	10.41	......	20.82
6	hom	[illegible]	21¾	43½	19.58	3.44	6.88	.91	1.25	12.48	7.10	......	14.20
7	alme	[illegible]	19⅔	39⅓	17.70	3.44	6.88	.84	1.25	12.41	5.29	......	10.58
[illegible]	[illegible]	[illegible]	3 11/15	7 11/12	3.53	3.44	6.88	.14	1.25	11.71	......	$8.18	......
				1,234 7/24	501.46	66.74	123.84	22.89	20.83	234.30	275.34	8.18	......
	[illegible]			61.⅛	......	......	......	......	......	28.20	......	......	32.10
	[illegible]			70.½	......	......	......	......	......	......	......	......	35.20

[illegible] ...cre on the crop of Irish [illegible] ...veraging $32.10, including [illegible] ...rly 8 to 107 bushels to the averaging 61¼ bushels. If, however, the one failure is not taken consideration, an average yield of 70½ bushels and an average ; of $35.20 to the acre are shown. These potatoes were dug on 21 and 22, 1906, and sold in the car at 90 cents a bushel. The s would have been larger but the price lower had they been dug veek later. In addition to this crop of potatoes with profits of $30 per acre, it would have been possible to have grown afters a good crop of Mexican June corn, or cowpeas, or other crops this same land and to have followed these by some winter crop. ıen it is considered that none of these tenants had ever before n Irish potatoes and had to be instructed in their cultivation the very beginning, the possibilities open to them in the future ey become more familiar with the crop can be seen.

e watermelons were sold in Alexandria and other neighboring s as they matured, bringing an average of 7 cents each. Watersıs grown upon bottom lands are poorer in quality than those pro-l upon the hill lands, and bring less upon the market. One load ese melons was sold on the State camp grounds, but the demand hem was slight because of their poor quality. It will be seen Table 2 that the yields varied from 0 to 600 melons to the acre, ging about 300 per acre for the 15 productive plots recorded. esults in money varied from a loss of $4.54 on half an acre to a ıt the rate of $85.83 to the acre, the average profit being $25.41.

2.—*Watermelon crop, 1906, of tenants on the plantation of William Polk, near Moreland, La.*

ame of tenant.	Number grown to the acre.	Area.	Expenses to the acre.				Gross receipts.	Net profit.	Loss.	Net profit to the acre.
			Fertilizer.	Seed.	Rent.	Total.				
		Acres.								
ible	600	8/13	$2.06	$1.02	$1.80	$4.88	$57.70	$52.82	......	$85.83
npson	600	½	2.06	1.02	1.46	4.54	39.00	34.46	......	68.92
m	450	9/13	2.06	1.02	2.03	5.11	34.50	29.39	......	42.45
man	400	6/13	2.06	1.22	1.35	4.63	23.85	19.22	......	41.64
'	410	11/26	2.06	1.02	1.24	4.32	17.50	13.18	......	31.15
on	300	9/13	2.06	1.02	2.03	5.11	25.00	19.89	......	28.73
n	280	½	2.06	1.02	1.46	4.54	18.50	13.96	......	27.92
ins	260	½	2.06	1.02	1.46	4.54	17.50	12.96	......	25.92
'	240	½	2.06	1.02	1.46	4.54	16.50	11.96	......	23.92
y	220	½	2.06	1.02	1.46	4.54	15.40	10.86	......	21.72
ford	214	11/18	2.06	1.02	1.79	4.87	18.00	13.13	......	21.48
ams	200	½	2.06	1.02	1.46	4.54	14.75	10.21	......	20.42
n	225	½	2.06	1.02	1.46	4.54	10.60	6.06	......	12.12
ards	103	13/30	1.04	1.02	1.17	3.23	6.30	3.07	......	7.08
npson	(a)	17/26	2.06	1.02	1.91	4.99	8.40	3.41	......	5.21
son	27	⅕	2.06	.81	.59	3.46	4.00	.54	......	2.70
er	0	½	2.06	1.02	1.46	4.54	......	......	$4.54	......
n	0	½	2.06	1.02	1.46	4.54	......	......	4.54	......
otal	4,529	9½	36.06	18.35	27.05	81.46	327.50	255.12	9.08	467.81
verage for the 15 plots recorded	300	......	......	......	......	......	......	......	......	25.41

[a] No record.

The figures in Tables 1 and 2 include the rent of the land and the cost of seed, fertilizers, and bagging for the potatoes, but do not include any expense for labor. The rent is figured at $5 an acre for the time actually taken to produce the crop.

From observations during the first year's work it was clearly seen that it was possible to establish a system of diversification on plantations and that the tenants were eager to raise other things than cotton, provided the owner was willing and they had some little instruction in the care of the new crops. However, it was noticed that true diversification is possible only where the tenant lives upon the land which he tills. When this is the case he can keep live stock, raise the necessary feed, provide pastures, and attend to the little details required by a diversified farm. Where a tenant lived a few miles from his holdings he lost too much time in going back and forth and was unable to give the necessary attention to his crops.[a] Because of this loss of time the owner during the past winter has moved many of his cottages from the old "quarters" to the holdings of the tenants. Many of the houses have been remodeled. A prize is offered to the tenant showing the most taste in the improvement of his home and environments.

All the tenants were much pleased with the experiment and desired to continue it. The owner is now one of the greatest diversification enthusiasts in the South. For 1907 he has planned to diversify further by adding sugar cane, alfalfa, and other crops to his list. (See Table 3.) He also has extended the work to his adjoining plantation.

Table 3 gives the names of the tenants on Emfield and Rosalie plantations, with the acreages which they have in each crop. The larger acreage is still in cotton and corn, but there are considerable areas in ribbon cane, alfalfa, and Irish potatoes, each tenant having from 1 to 5 acres of each of these crops. Then there are smaller areas in watermelons, cabbages, and sweet potatoes.

---

[a] The cabbage crop referred to might have been saved had the tenants lived near enough so as to have been able to water it.

E 3.—*Kinds of crops, with acreages, grown by tenants of William Polk in 1907, with number of live stock kept.*

of tenant and nber in his ily.	Cotton.	Cane.	Potatoes.	Corn and peas.	Alfalfa.	Melons.	Sorghum.	Cabbage.	Sweet potatoes.	Miscellaneous garden vegetables.	Mules.	Horses.	Cattle.	Hogs.
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*No.*	*No.*	*No.*	*No.*
ggins (2)	22	¾	2	23	2	1	¼	......	½	¼	2	1	3	10
ferson (4)	10	2	2	8	2	½	¼	......	½	¼	3	1	3	9
lmer (8)	26	1¾	3	8	1½	1	¼	½	½	¼	1	2	....	3
kson (2)	13	½	2	7	3	1	¼	......	½	¼	1	....	....	1
acener (5)	16	3	3	15	......	½	¼	½	1	1	2	1	5	5
lliams (6)	30	¼	5	16	2	1	¼	½	1	¼	3	1	3	8
ey (8)	25	3½	4	14	2½	½	¼	½	½	1	3	1	2	7
son (10)	20	5	5	13	2	1	¼	½	1	¼	2	1	4	15
ompson (4)	20	6	4	12	2½	1	1	1½	1	¼	2	4	6	4
lom (10)	48	1	12	38	6½	1	½	1	2	1	7	2	14	20
mble (7)	17	1½	2	9½	2	1	......	½	½	¼	1	1	8	10
ompson (3)	15	3	3	8	1	½	¼	......	½	¼	1	2	4	5
se (4)	18	1¾	3½	7	1½	1	¼	1	½	¼	2	2	....	6
wards (8)	28	2	3¾	15	1½	1	¼	1¼	1	1	3	1	5	3
nson (5)	14	½	2	10	1½	2	¼	¼	½	¼	2	1	1	3
ng (10)	17	½	2	9	2	½	¼	¼	½	¼	2	1	2	3
iffin (6)	15	3	4	10	2	1	¼	¼	½	¼	2	1	2	10
ster (9)	20	1	4	12	2	1	¼	¼	½	¼	2	1	....	6
xter (5)	19	½	2	9	1	1	¼	¼	½	¼	....	3	....	1
rdy (6)	15	¼	2	8	1½	1	......	......	½	¼	1	1	2	7
you (3)	13	1	2	6	1	1	¼	......	½	¼	2	1	....	1
ldon (2)	12	½	2	10	......	1	¼	1	1	1	1	1	2	3
hley (4)	12	......	3	6	......	½	¼	¼	½	¼	2	....	3	5
om (2)	12	......	2	8	......	½	¼	......	½	¼	1	1	4	2
letto (3)	40	......	20	10	......	1	......	2	......	¼	2	2	1	....
rcinto (6)	17	......	2½	2½	......	1	¼	3	1½	4	2	....	....	2
mero (5)	26	......	3	5	......	¾	¼	......	½	1	2	....	....	2
dman (4)	30	5	......	20	......	1	1	½	½	¼	4	1	6	2
rnado (5)	18	3	3	12	½	1	¼	½	½	¼	2	....	....	1
liams (2)	15	1½	2¼	7	......	½	¼	½	½	¼	1	1	2	1
nie (4)	25	1	3	15	1	1	¼	......	1	¼	2	2	3	7
wn (5)	27	5	1	11	3	1	¼	½	½	¼	2	1	1	16
own (9)	23	......	4	6	......	1	¼	½	1	¼	2	....	....	2
xon (12)	40	6	5	15	2	1	¼	½	2	¼	2	4	5	26
wford (6)	22	5	2	14	2	1	¼	½	1	¼	3	2	1	4
rrel (3)	25	1	4	15	3	1	¼	1	½	¼	4	....	2	1
w (2)	12	......	......	3	......	......	......	......	½	¼	....	....	....	2
Total	777	66¾	129	417	52½	32¾	10¼	19¼	27½	18⅜	76	44	94	213

n addition to the crops specified, three tenants had an eighth of an each in onions; two, one-fourth acre each in peanuts; one, one-th acre in sweet corn; and one, 6 acres in Johnson grass, while one nt had three-fourths of an acre each in clover and in oats and h, one-half an acre each in radishes and rape, and an eighth of an each in tomatoes, beans, okra, and cantaloupes.

he income will be derived from Irish potatoes, watermelons, cot- and ribbon cane, in the order given, while many of the tenants also have small quantities of sweet potatoes, cabbages, and other k to sell, and perhaps a little pork. In addition to this, these nts have had their own milk, butter, eggs, and vegetables; they e raised their own poultry, pork, and hay, and at the end of the will be much better off than when they paid out for these things hey received for the cotton crop.

CONCLUSION.

The tenant's prosperity is identical with that of the planter. It is therefore to the advantage of the planter to encourage diversified farming among his tenants. It is hoped that many planters will learn from the description of these experiments in Louisiana not only the benefits of diversification but also how to start the work. Not every one will be so situated as to follow this outline exactly, but the principle is plain and some plan can be evolved which will work equally well under other conditions.

FARMERS' BULLETINS.

The following is a list, by number, of the Farmers' Bulletins available for distribution. The bulletins entitled "Experiment Station Work" give in brief the results of experiments performed by the State experiment stations. Titles of other bulletins are self-explanatory. Bulletins in this list will be sent free to any address in the United States on application to a Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

22. The Feeding of Farm Animals. Pp. 40.
24. Hog Cholera and Swine Plague. Pp. 16.
27. Flax for Seed and Fiber. Pp. 16.
28. Weeds: And How to Kill Them. Pp. 30.
30. Grape Diseases on the Pacific Coast. Pp. 15.
32. Silos and Silage. Pp. 30.
33. Peach Growing for Market. Pp. 24.
34. Meats: Composition and Cooking. Pp. 31.
35. Potato Culture. Pp. 24.
36. Cotton Seed and Its Products. Pp. 16.
42. Facts About Milk. Pp. 32.
44. Commercial Fertilizers. Pp. 38.
47. Insects Affecting the Cotton Plant. Pp. 32.
48. The Manuring of Cotton. Pp. 16.
51. Standard Varieties of Chickens. Pp. 48.
52. The Sugar Beet. Pp. 48.
54. Some Common Birds. Pp. 48.
55. The Dairy Herd. Pp. 30.
56. Experiment Station Work—I. Pp. 30.
58. The Soy Bean as a Forage Crop. Pp. 24.
59. Bee Keeping. Pp. 48.
60. Methods of Curing Tobacco. Pp. 24.
61. Asparagus Culture. Pp. 40.
62. Marketing Farm Produce. Pp. 31.
63. Care of Milk on the Farm. Pp. 40.
64. Ducks and Geese. Pp. 55.
65. Experiment Station Work—II. Pp. 32.
66. Meadows and Pastures. Pp. 30.
69. Experiment Station Work—III. Pp. 32.
71. Essentials in Beef Production. Pp. 24.
73. Experiment Station Work—IV. Pp. 32.
74. Milk as Food. Pp. 39.
77. The Liming of Soils. Pp. 24.
78. Experiment Station Work—V. Pp. 32.
79. Experiment Station Work—VI. Pp. 27.
80. The Peach Twig-Borer. Pp. 16.
81. Corn Culture in the South. Pp. 24.
82. The Culture of Tobacco. Pp. 22.
83. Tobacco Soils. Pp. 23.
84. Experiment Station Work—VII. Pp. 32.
85. Fish as Food. Pp. 32.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
91. Potato Diseases and Treatment. Pp. 15.
92. Experiment Station Work—IX. Pp. 30.
93. Sugar as Food. Pp. 31.
97. Experiment Station Work—X. Pp. 32.
98. Suggestions to Southern Farmers. Pp. 48.
99. Insect Enemies of Shade Trees. Pp. 30.
100. Hog Raising in the South. Pp. 40.
101. Millets. Pp. 30.
102. Southern Forage Plants. Pp. 48.
103. Experiment Station Work—XI. Pp. 30.
104. Notes on Frost. Pp. 24.
105. Experiment Station Work—XII. Pp. 32.
106. Breeds of Dairy Cattle. Pp. 48.
107. Experiment Station Work—XIII. Pp. 32.
110. Rice Culture in the United States. Pp. 28.
112. Bread and Bread Making. Pp. 40.
113. The Apple and How to Grow It. Pp. 32.
114. Experiment Station Work—XIV. Pp. 28.
116. Irrigation in Fruit Growing. Pp. 48.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 30.
120. Insects Affecting Tobacco. Pp. 32.
121. Beans, Peas, and Other Legumes as Food. Pp. 38.
122. Experiment Station Work—XVI. Pp. 32.
124. Experiment Station Work—XVII. Pp. 32.
125. Protection of Food Products from Injurious Temperatures. Pp. 24.
126. Practical Suggestions for Farm Buildings. Pp. 48.
127. Important Insecticides. Pp. 46.
128. Eggs and Their Uses as Food. Pp. 40.
131. Household Tests for Detection of Oleomargarine and Renovated Butter. Pp. 10.
132. Insect Enemies of Growing Wheat. Pp. 38.
133. Experiment Station Work—XVIII. Pp. 32.
134. Tree Planting in Rural School Grounds. Pp. 32.
135. Sorghum Sirup Manufacture. Pp. 40.
137. The Angora Goat. Pp. 48.
138. Irrigation in Field and Garden. Pp. 40.
139. Emmer: A Grain for the Semiarid Regions. Pp. 16.
140. Pineapple Growing. Pp. 48.
142. Principles of Nutrition and Nutritive Value of Food. Pp. 48.
144. Experiment Station Work—XIX. Pp. 32.
145. Carbon Bisulphid as an Insecticide. Pp. 28.
147. Winter Forage Crops for the South. Pp. 40.
149. Experiment Station Work—XX. Pp. 32.
150. Clearing New Land. Pp. 24.
151. Dairying in the South. Pp. 48.
152. Scabies in Cattle. Pp. 32.
154. The Home Fruit Garden: Preparation and Care. Pp. 16.
155. How Insects Affect Health in Rural Districts. Pp. 19.
156. The Home Vineyard. Pp. 22.
157. The Propagation of Plants. Pp. 24.
158. How to Build Small Irrigation Ditches. Pp. 28.
159. Scab in Sheep. Pp. 48.
161. Practical Suggestions for Fruit Growers. Pp. 30.
162. Experiment Station Work—XXI. Pp. 32.
164. Rape as a Forage Crop. Pp. 16.
165. Silkworm Culture. Pp. 32.
166. Cheese Making on the Farm. Pp. 16.
167. Cassava. Pp. 32.
169. Experiment Station Work—XXII. Pp. 32.
170. Principles of Horse Feeding. Pp. 44.
172. Scale Insects and Mites on Citrus Trees. Pp. 43.
173. Primer of Forestry. Pp. 48.
174. Broom Corn. Pp. 30.
175. Home Manufacture and Use of Unfermented Grape Juice. Pp. 16.
176. Cranberry Culture. Pp. 20.
177. Squab Raising. Pp. 32.
178. Insects Injurious in Cranberry Culture. Pp. 32.
179. Horseshoeing. Pp. 30.
181. Pruning. Pp. 39.
182. Poultry as Food. Pp. 40.
183. Meat on the Farm: Butchering, Curing, and Keeping. Pp. 37.
185. Beautifying the Home Grounds. Pp. 24.
186. Experiment Station Work—XXIII. Pp. 32.
187. Drainage of Farm Lands. Pp. 38.
188. Weeds Used in Medicine. Pp. 45.
190. Experiment Station Work—XXIV. Pp. 32.
192. Barnyard Manure. Pp. 32.
193. Experiment Station Work—XXV. Pp. 32.
194. Alfalfa Seed. Pp. 14.
195. Annual Flowering Plants. Pp. 48.
196. Usefulness of the American Toad. Pp 16.

197. Importation of Game Birds and Eggs for Propagation. Pp. 30.
198. Strawberries. Pp. 24.
199. Corn Growing. Pp. 32.
200. Turkeys. Pp. 40.
201. Cream Separator on Western Farms. Pp. 23.
202. Experiment Station Work—XXVI. Pp. 32.
203. Canned Fruits, Preserves, and Jellies. Pp. 32.
204. The Cultivation of Mushrooms. Pp. 24.
205. Pig Management. Pp. 45.
206. Milk Fever and Its Treatment. Pp. 16.
208. Varieties of Fruits Recommended for Planting. Pp. 48.
209. Controlling the Boll Weevil in Cotton Seed and at Ginneries. Pp. 32.
210. Experiment Station Work—XXVII. Pp. 32
211. The Use of Paris Green in Controlling the Cotton Boll Weevil. Pp. 23.
213. Raspberries. Pp. 38.
215. Alfalfa Growing. Pp. 40.
217. Essential Steps in Securing an Early Crop of Cotton. Pp. 16.
218. The School Garden. Pp. 40.
219. Lessons from the Grain Rust Epidemic of 1904. Pp. 24.
220. Tomatoes. Pp. 32.
221. Fungous Diseases of the Cranberry. Pp. 16.
222. Experiment Station Work—XXVIII. Pp. 32.
223. Miscellaneous Cotton Insects in Texas. Pp. 24.
224. Canadian Field Peas. Pp. 16.
225. Experiment Station Work—XXIX. Pp. 32.
226. Relation of Coyotes to Stock Raising in the West. Pp. 24.
227. Experiment Station Work—XXX. Pp. 32.
228. Forest Planting and Farm Management. Pp. 22.
229. The Production of Good Seed Corn. Pp. 24.
231. Spraying for Cucumber and Melon Diseases. Pp. 24.
232. Okra: Its Culture and Uses. Pp. 16.
233. Experiment Station Work—XXXI. Pp. 32.
234. The Guinea Fowl. Pp. 24.
235. Preparation of Cement Concrete. Pp. 32.
236. Incubation and Incubators. Pp. 32.
237. Experiment Station Work—XXXII. Pp. 32.
238. Citrus Fruit Growing in the Gulf States. Pp. 48.
239. The Corrosion of Fence Wire. Pp. 32.
241. Butter Making on the Farm. Pp. 32.
242. An Example of Model Farming. Pp. 16.
243. Fungicides and Their Use in Preventing Diseases of Fruits. Pp. 32.
244. Experiment Station Work—XXXIII. Pp. 32.
245. Renovation of Worn-Out Soils. Pp. 16.
246. Saccharine Sorghums for Forage. Pp. 37.
248. The Lawn. Pp. 20.
249. Cereal Breakfast Foods. Pp. 36.
250. The Prevention of Wheat Smut and Loose Smut of Oats. Pp. 16.
251. Experiment Station Work—XXXIV. Pp. 32.
252. Maple Sugar and Sirup. Pp. 36.
253. The Germination of Seed Corn. Pp. 16.
254. Cucumbers. Pp. 30.
255. The Home Vegetable Garden. Pp. 47.
256. Preparation of Vegetables for the Table. Pp. 48.
257. Soil Fertility. Pp. 39.
258. Texas or Tick Fever and Its Prevention. Pp. 45.
259. Experiment Station Work—XXXV. Pp. 32.
260. Seed of Red Clover and Its Impurities. Pp. 24.
261. The Cattle Tick. Pp. 22.
262. Experiment Station Work—XXXVI. Pp. 32.
263. Practical Information for Beginners in Irrigation. Pp. 40.
264. The Brown-Tail Moth and How to Control It. Pp. 22.
266. Management of Soils to Conserve Moisture. Pp. 30.
267. Experiment Station Work—XXXVII. Pp. 32.
268. Industrial Alcohol: Sources and Manufacture. Pp. 45.
269. Industrial Alcohol: Uses and Statistics. Pp. 29.
270. Modern Conveniences for the Farm Home. Pp. 48.
271. Forage Crop Practices in Western Oregon and Western Washington. Pp. 39.
272. A Successful Hog and Seed-Corn Farm. Pp. 16.
273. Experiment Station Work—XXXVIII. Pp 32.
274. Flax Culture. Pp. 36.
275. The Gipsy Moth and How to Control It. Pp 22.
276. Experiment Station Work—XXXIX. Pp. 32.
277. The Use of Alcohol and Gasoline in Farm Engines. Pp. 40.
278. Leguminous Crops for Green Manuring. Pp. 27.
279. A Method of Eradicating Johnson Grass. Pp. 16.
280. A Profitable Tenant Dairy Farm. Pp. 16.
281. Experiment Station Work—XL. Pp. 32.
282. Celery. Pp. 36.
283. Spraying for Apple Diseases and the Codling Moth in the Ozarks. Pp. 42.
284. Insect and Fungous Enemies of the Grape East of the Rocky Mountains. Pp. 48.
285. The Advantage of Planting Heavy Cotton Seed. Pp. 16.
286. Comparative Value of Whole Cotton Seed and Cotton-Seed Meal in Fertilizing Cotton. Pp. 14.
287. Poultry Management. Pp. 48.
288. Nonsaccharine Sorghums. Pp. 28.
289. Beans. Pp. 28.
290. The Cotton Bollworm. Pp 32.
291. Evaporation of Apples. Pp. 38.
292. Cost of Filling Silos. Pp. 15.
293. Use of Fruit as Food. Pp. 38.
294. Farm Practice in the Columbia Basin Uplands. Pp. 30.
295. Potatoes and Other Root Crops as Food. Pp. 45.
296. Experiment Station Work—XLI. Pp. 32.
297. Method of Destroying Rats. Pp. 8.
298. The Food Value of Corn and Corn Products. Pp. 40.
299. Diversified Farming Under the Plantation System. Pp. 14.
300. Some Important Grasses and Forage Plants for the Gulf Coast Region. Pp. 15.
301. Home-Grown Tea. Pp. 16.
302. Sea Island Cotton: Its Culture, Improvement, and Diseases. Pp. 48.
303. Corn Harvesting Machinery. Pp. 32.
304. Growing and Curing Hops. Pp. 39.
305. Experiment Station Work—XLII. Pp. 32.
306. Dodder in Relation to Farm Seeds. Pp. 27.
307. Roselle: Its Culture and Uses. Pp. 16.
308. Game Laws for 1907. Pp. 52.
309. Experiment Station Work—XLIII. Pp. 32.
310. A Successful Alabama Diversification Farm. Pp. 24.
311. Sand-Clay and Burnt-Clay Roads. Pp. 20.
312. A Successful Southern Hay Farm. Pp. 15.
313. Harvesting and Storing Corn. Pp. 32.
314. A Method of Breeding Early Cotton to Escape Boll-Weevil Damage. Pp. 24.
315. Progress in Legume Inoculation. Pp. 20.
316. Experiment Station Work—XLIV. Pp. 32.
317. Experiment Station Work—XLV. Pp. 32.
318. Cowpeas. Pp. 26.
319. Demonstration Work in Cooperation with Southern Farmers. Pp. 23.
320. Experiment Station Work—XLVI. Pp. 32.
321. The Use of the Split-Log Drag on Earth Roads. Pp. 14.
322. Milo as a Dry-Land Grain Crop. Pp. 23.
323. Clover Farming on the Sandy Jack-Pine Lands of the North. Pp. 24.
324. Sweet Potatoes. Pp. 39.
325. Small Farms in the Corn Belt. Pp. 29.
326. Building up a Run-Down Cotton Plantation. Pp. 22.
327. The Conservation of Natural Resources. Pp. 12.
328. Silver Fox Farming. Pp. 22.

O

U. S. DEPARTMENT OF AC

FARMERS' BULLETIN 300.

SOME IMPORTANT GRASSES AND FORAGE PLANTS FOR THE GULF COAST REGION.

BY

S. M.

Special Agent,
Bureau of *nt*

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., May 18, 1907.

Sir: I have the honor to transmit herewith a paper entitled "Some Important Grasses and Forage Plants for the Gulf Coast Region," and recommend that it be published as a Farmers' Bulletin. This paper was prepared by Prof. S. M. Tracy, under the direction of the Agriculturist in charge of the Farm Management Investigations of this Bureau. Professor Tracy has given careful study for several years past to the subjects discussed in these pages.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Mexican clover
Beggarweed
Velvet beans
Guinea grass
Para grass

ILLUSTRATIONS.

Fig. 1. Mexican clover in corn, Monticello, Fla
2. Florida beggarweed in corn, Monticello, Fla
3. Velvet beans in corn, De Funiak Springs, Fla
4. Guinea grass, Biloxi, Miss
5. Para grass, third year, Kingsville, Tex

B. P. I.—291.

SOME IMPORTANT GRASSES AND FORAGE PLANTS FOR THE GULF COAST REGION.

MEXICAN CLOVER.

Mexican clover (*Richardsonia scabra*) (fig. 1), sometimes called "pusley" or "purslane," though entirely different from the plant known by those names in the North, is not a true clover, but belongs to the same family as the madder, poverty weed, and a number of other common plants. It is an annual which grows about as large and which has much the same habit of growth as the common red clover, but its leaves are opposite and simple instead of being alternate and 3-parted, as in the true clovers. It grows most abundantly in sandy cultivated fields from which early crops have been removed, and often makes a heavy growth in corn and cotton fields after those crops have been laid by. It is seldom planted, as, like crab-grass and beggarweed, with which it is usually found, it makes a volunteer growth late in the season and the yield would be increased very little if it were sown early and the ground given up to it through the entire year. It is common in old fields, from southern Florida to central Georgia and westward to southern Mississippi, making a fair growth on soils too poor and sandy for most other crops and being more thrifty on fertile fields, where it often makes a growth of 4 to 5 feet.

Mexican clover is used both for hay and for grazing. While the hay is somewhat hard to cure when cut early and is not of the best quality, it is eaten readily by most animals. It is usually more or less mixed with crab-grass and beggarweed, and adds largely to the bulk and value of a volunteer crop of these. When used for grazing, Mexican clover is more valuable for hogs than for other stock. It can be grazed from about May until after heavy frosts, and will then reseed the ground abundantly. The seeds are very small and difficult to save, though they are sometimes beaten out with flails or gathered from the bottom of a mow in which the hay has been stored. For seeding, 4 or 5 pounds per acre is sufficient, but the more common method of distributing the plant is by mowing after the seed is matured, and then scattering the hay over the field on which the crop is wanted the following year.

Opinions as to the value of Mexican clover differ widely, some farmers regarding it as a worthless weed, while others praise it very highly. One grower in northern Florida, who has cultivated it for fifteen years, reports that during last summer he kept 4 horses and 20 hogs for eight months on a field of 7 acres. This field had been in oats the previous season, and the growth, though somewhat mixed with crab-grass and beggarweed, was mostly Mexican clover. Another grower in extreme western Florida, who has grown this forage plant quite largely for twelve years, declares that it is a valuable volunteer plant in his cultivated fields, as it makes a heavy growth on ground which would otherwise be vacant and adds largely to the yields of lands growing cowpeas, crab-grass, and other fall hay crops. Cattle and mules eat it readily, while hogs graze it with relish. When not required for forage, it gives a needed protection to the soil during winter, and is so thoroughly decayed by spring that it is not in the way of the plow. A liveryman at Thomasville, Ga., where the plant is quite common, says that it is as nearly worthless as anything ever made into hay, and that he will not use hay with which it is mixed. A southern Mississippi grower, on the contrary, says: "Cattle will pick it out from any other hay and eat it in preference to any." Similar conflicting statements could be quoted from nearly every section in the region in which it is grown.

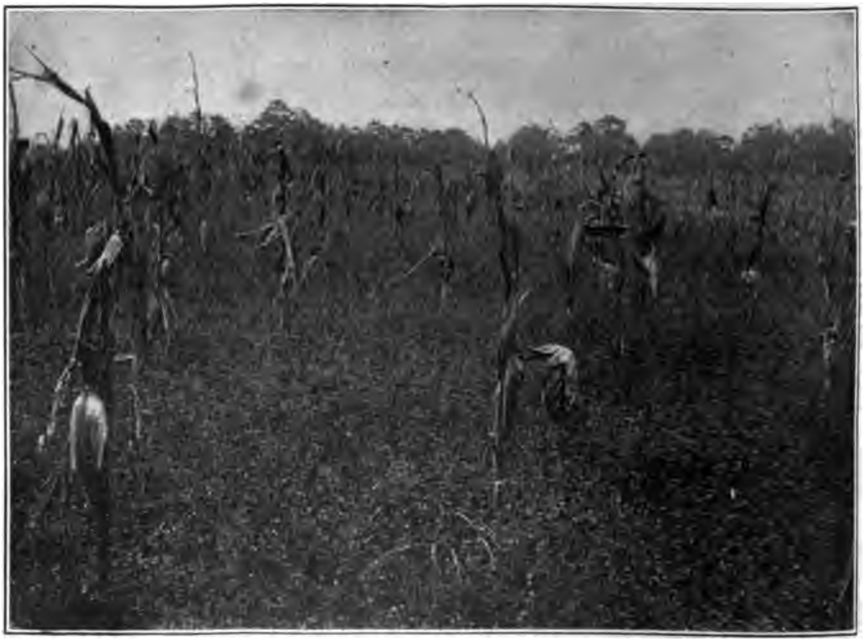


FIG. 1.- Mexican clover in corn, Monticello, Fla.

While Mexican clover is not a nitrogen-gathering plant, like the true clovers, its growth is usually volunteer and so costs nothing; it protects the surface of the ground from the scorching sun in summer and from washing rains in winter, and adds to the fertility of the soil by providing humus. The plant should be regarded as an inexpensive substitute for something better rather than as one to be generally cultivated at much expense.

BEGGARWEED.

Beggarweed (*Desmodium tortuosum*) is an important forage plant from southern Florida northward to southern Georgia and Alabama, though it is seldom found west of the Alabama River. It is an annual legume which is common as a volunteer growth in old fields with sandy soils, making its best growth late in the season—at the same time that crab-grass is growing most rapidly. It is erect in habit, reaching a height of 5 to 7 feet on good soils, and is used for hay, silage, and grazing. Like crab-grass, with which it usually grows, it makes a scattering and uneven volunteer growth on land which has not been plowed during the year, though, when occasional strips are left standing at the second cutting and the field is afterwards harrowed crosswise to scatter the seed, a good crop is often secured the second season after plowing. The volunteer growth, however, as is the case with all volunteer crops, is uneven and somewhat uncertain, and the better practice is to reseed the ground after oats, melons, or other early crops have been removed, using 25 to 30 pounds of rough seed to the acre. The seed is usually saved by stripping it from the plants by hand, the labor making the seed cost about 3 cents a pound.

In regions where beggarweed is grown most commonly it is seldom found as a volunteer crop on newly cleared lands, but it is more or less abundant in nearly all old fields, especially in cornfields (fig. 2) and cotton fields, where it springs up after the crop is laid by and where it furnishes a large amount of fine grazing after these crops have been gathered. Some cotton growers object to beggarweed in their fields, as the immature seeds are somewhat rough and, when switched about by the wind, often pull the seed cotton from the bolls. It is easily killed by a single cultivation in late summer and soon disappears from fields which are not plowed.

When used for hay beggarweed should be cut about the time it is beginning to bloom, in June or July, and a second cutting can then be made a few weeks later. When cut at the right time and properly cured it has no superior for hay, but it must be handled with care and should be windrowed as soon as wilted to prevent the leaves from dropping. If allowed to become too old before it is cut, many of the lower leaves are lost and the stems become hard and woody, though if run through a shredder the stems are eaten readily by stock, even when quite mature. It makes a yield of from 1 to 2 tons per acre. The hay, especially that made from the second cutting, is usually mixed with more or less crab-grass, cockspur, and Mexican clover. When well cured the hay is very fattening; dairymen prize it highly for the flavor which it gives to milk when fed during the winter, and they often sow the seed with cowpeas for that reason.

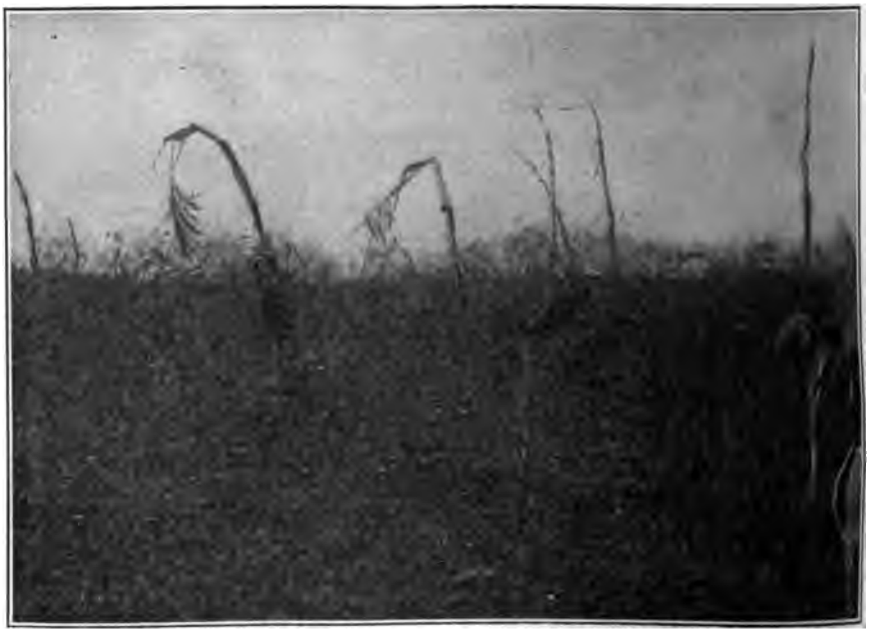


FIG. 2.—Florida beggarweed in corn, Monticello, Fla.

Although not sufficiently bulky for use alone in filling a silo, a little beggarweed adds greatly to the value of silage, as it gives a marked "June" flavor to butter, even when fed in midwinter. Its greatest value, however, is as a grazing plant for late summer and fall. All kinds of stock eat it with relish and make rapid gains in flesh while pasturing on it.

While beggarweed is a crop of secondary importance and fields are seldom used for growing it alone, it is a welcome addition to any hay crop, and when it is so abundant as to afford good grazing it will fatten horses, mules, and cattle more quickly than any other plant.

VELVET BEANS.

The velvet bean (*Mucuna utilis*) is the most rank-growing legume cultivated for forage and is one of the most valuable annual plants both for the production of feed and as a restorative crop in a rotation. It is not as good as the cowpea for making hay, as its growth is so strong and the vines are so long and tangled that it is difficult to cut and cure, but it makes an immense amount of fall and winter grazing, produces seed abundantly, and leaves the soil in a fine condition for any succeeding crop. It needs a long season (about eight months) for maturing, and so is rarely grown north of a line from Savannah, Ga., westward to Austin, Tex., and is most common on the sandy lands east of the Mississippi River. It is grown more extensively in Florida than elsewhere, there probably being more acres devoted to the crop in that State than in all the rest of the country.

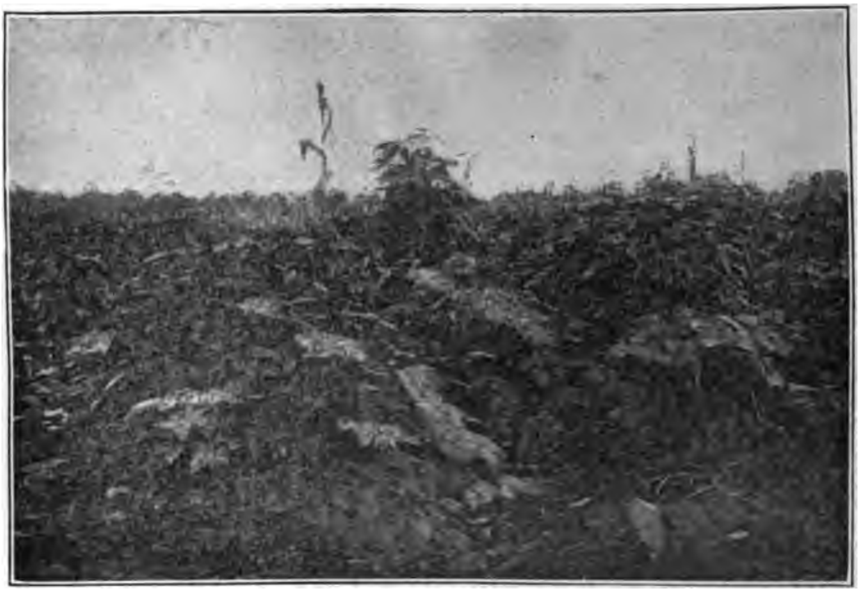


FIG. 3.—Velvet beans in corn, De Funiak Springs, Fla.

The velvet bean is one of the best plants for newly cleared lands, as its growth is so dense and rapid that it smothers all weeds, sprouts, and grass and as it "civilizes" the soil better than any other crop. The vines should be given some support to keep them up from the ground, as otherwise they will not fruit well or make the most vigorous growth. Poles are sometimes used for that purpose, but are expensive and troublesome, and cornstalks are more commonly used (fig. 3). Some strong-growing variety of corn, often the "Mexican June," is planted at the same time as the beans, or a few days earlier, and the stalks give the needed support to the vines. Some planters prefer to top the corn as soon as the ears are fairly mature, claiming that the part of the stalk which is left is not pulled over by the vines as easily as is the whole stalk; others plant three rows of corn and one of beans, claiming that in that way they get a good crop of both corn and beans; still others plant the corn in 7-foot rows and when it is about a foot high plant beans in the middles. When planted in that way the corn matures a full crop and the bean vines have a fair support. Planting is done as early in the spring as is safe, as late plantings never make seed as freely as do those made as soon as there is no further danger from late frosts. From 6 to 8 quarts of seed per acre are used. The heaviest yields of both vines and seed are undoubtedly secured when the beans are planted in every row at the same time the corn is planted, but with such treatment the yield of corn is usually small.

With a good support for the vines the yield of seed is very heavy—from 40 to 75 bushels per acre. The seed is gathered by hand at a cost of from 15 to 20 cents for a barrel of pods, which will make a little more than a bushel of shelled beans. Thrashing is rather difficult, as the pods are tough and very close together, but at present prices the seed alone makes a profitable crop. When a crop of seed has been gathered, the vines and immature seeds which are left still make rich grazing, and the fertilizing effect of the crop on the soil is little changed.

A dairyman in northern Florida reports that he had 20 acres of velvet beans last year and began grazing them just before frost. He grazed 30 cows one-half of each day for twenty-seven days, and then gathered 20,000 pounds of beans in pods. These were ground, steamed, and mixed with wheat bran and cotton-seed meal, which made a rich feed for his cows. Another grower in southern Georgia states that he grazed 100 cattle for four months on 80 acres of the beans, the cattle beginning to graze immediately after the first frost. He follows a rotation of cotton, corn followed by winter oats, and velvet beans after the oats are harvested in May. This rotation makes the beans mature too late for their best growth, but gives a good profit on the work, as the cotton this year yielded a trifle more than a bale to the acre on land where beans were grown last year, and that without any other fertilizer. He plants the beans about 1 by 3½ feet apart and cultivates twice.

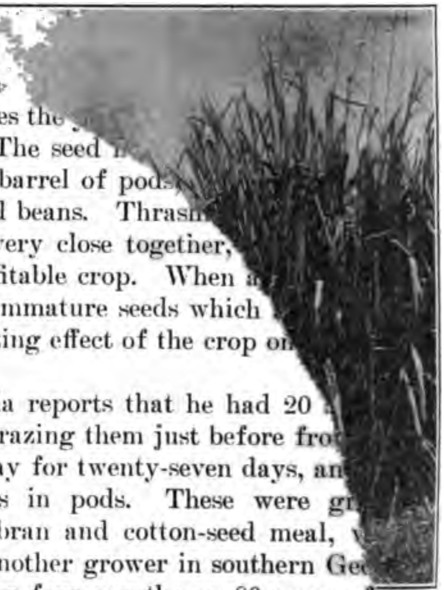
A grower in western Florida last year planted a field of 6 acres of velvet beans early in April. In June he put 60 hogs in the field. These hogs ate the volunteer Mexican clover first, and then the volunteer beggarweed, doing so little harm to the beans that 12 tons of hay were cut from the field in September. The same grower states that beginning in October seventy days of grazing on velvet beans will make a steer ready for market.

Grazing usually begins at about the time of the first frost and may be continued until February or March, as both the vines and the beans remain in edible condition through the winter. The beans are quite hard when matured and dry, but are eaten well in the fall or whenever they become slightly softened by rains or by lying on the damp ground, so that all are consumed before the ground is plowed in the spring. Dairymen find that fall grazing is the greatest stimulus to milk production, while beef growers value velvet beans more highly for winter feeding. The dry beans are so hard that they do not rank high for feeding. Horses do not eat them well, as the short, stiff hairs on the pods soon give them
sore mouths, while grinding and steamin ne also gives his
nary purposes. inter. A grower in southern
The plant is seldom used zing grass we have." Another says:
cutting and curing. W her grass." Similar statements are made
Alabama and southern Mississippi.
fine quality, but wh Guinea grass is as a soiling crop, and it makes
stems become dry or that purpose than any other grass we have. If
than the cowpe or 4 feet high, the stem is very tender and succulent,
The princi tire growth consisting of rather broad, smooth leaves.
grazing, an this stage the whole plant is eaten with relish by all kinds
region. It When allowed to grow until it makes seed the stems become
produces woody, though the leaves remain green and are eaten well.
through cially valuable to those who have only small places and who
crimson constant supply of green feed for a few horses or cows. Its
f profitable cultivation is about the same as that for Para
including the whole of Florida and a narrow strip along the
Gu westward to Texas south of latitude 31°.
whi
isl

PARA GRASS.

Para grass (*Panicum molle*) (fig. 5), which was introduced from South America many years ago, is now common in central and southern Florida and is rapidly coming into favor farther west, especially in southern Texas. It is a rank-growing perennial which spreads by surface runners, which are often 30 or more feet in length and which form roots at each joint. As soon as the ground becomes fairly covered with these runners the younger stems assume a more erect position, reaching a height of 3 to 5 feet and producing a heavy yield for hay or grazing. Although this grass spreads so rapidly by its long runners, it is more easily killed than Bermuda or Johnson grass, as the runners are wholly on the surface of the ground, and it can be killed by a very shallow plowing followed by a thorough

Guinea grass is propagated either by divisions of the old roots or by seeds. When roots are used the old clumps are dug out early in spring and divided to make as many sets as can be secured with a few fibrous roots attached. When these sets are planted on good ground they will give a good cutting of hay or be ready for grazing in May. Seeds are planted at the same season as the roots, it being the usual practice to plant the seeds thickly in drills and then transplant the seedlings as soon as they are 3 or 4 inches high. Volunteer seedlings are often found in abundance where the old plants have been allowed to mature seed. Sets are more expensive and more troublesome to handle than are seedlings, but will give an earlier and heavier yield



every row at the sa...
ment the yield of corn is usually
With a good support for the vines the
from 40 to 75 bushels per acre. The seed
cost of from 15 to 20 cents for a barrel of pod
little more than a bushel of shelled beans. Thras
cult, as the pods are tough and very close together,
prices the seed alone makes a profitable crop. When
has been gathered, the vines and immature seeds which
make rich grazing, and the fertilizing effect of the crop o
little changed.

A dairyman in northern Florida reports that he had 20
velvet beans last year and began grazing them just before fro
grazed 30 cows one-half of each day for twenty-seven days, an
gathered 20,000 pounds of beans in pods. These were g
steamed, and mixed with wheat bran and cotton-seed meal,
made a rich feed for his cows. Another grower in southern Ge
states that he grazed 100 cattle for four months on 80 acres of
beans, the cattle beginning to graze immediately after the first fros. He follows a rotation of cotton, corn followed by winter oats, and velvet beans after the oats are harvested in May. This rotation makes the beans mature too late for their best growth, but gives a good profit on the work, as the cotton this year yielded a trifle more than a bale to the acre on land where beans were grown last year, and that without any other fertilizer. He plants the beans about 1 by 3½ feet apart and cultivates twice.

A grower in western Florida last year planted a field of 6 acres of velvet beans early in April. In June he put 60 hogs in the field. These hogs ate the volunteer Mexican clover first, and then the volunteer beggarweed, doing so little harm to the beans that 12 tons of hay were cut from the field in September. The same grower states cuttings about once every three or four weeks until its growth is checked by frost. In the most favorable part of the season cuttings may be made once in 10 or 12 days, but such rapid growth usually continues only a few weeks. When allowed to stand too long the stalks become hard and woody. This grass makes the best feed if cut when 24 to 36 inches high.

It is difficult to estimate the yield of hay per acre, as Guinea grass is commonly used only for soiling or grazing. Its habit of growing in large clumps makes it difficult to use a machine in cutting this grass for hay. One grower who has used it many years for soiling reports that he can feed 4 head of cattle per acre through the entire season, while another, who is growing cattle extensively, reports that he grazes 3 head per acre through the year, though he also gives his cattle a little Para hay during the winter. A grower in southern Florida says: " It is the best grazing grass we have." Another says: "It yields more than any other grass." Similar statements are made by growers in southern Alabama and southern Mississippi.

The chief value of Guinea grass is as a soiling crop, and it makes more good feed for that purpose than any other grass we have. If cut when only 3 or 4 feet high, the stem is very tender and succulent, nearly the entire growth consisting of rather broad, smooth l When cut at this stage the whole plant is eaten with relish by all kin of stock. When allowed to grow until it makes seed the stems beco hard and woody, though the leaves remain green and are eaten well. It is specially valuable to those who have only small places and who wish a constant supply of green feed for a few horses or cows. Its range of profitable cultivation is about the same as that for Para grass, including the whole of Florida and a narrow strip along the coast westward to Texas south of latitude 31°.

PARA GRASS.

Para grass (*Panicum molle*) (fig. 5), which was introduced from South America many years ago, is now common in central and southern Florida and is rapidly coming into favor farther west, especially in southern Texas. It is a rank-growing perennial which spreads by surface runners, which are often 30 or more feet in length and which form roots at each joint. As soon as the ground becomes fairly covered with these runners the younger stems assume a more erect position, reaching a height of 3 to 5 feet and producing a heavy yield for hay or grazing. Although this grass spreads so rapidly by its long runners, it is more easily killed than Bermuda or Johnson grass, as the runners are wholly on the surface of the ground, and it can be killed by a very shallow plowing followed by a thorough raking. While it makes a fair growth on rather dry soil, it does much better on damp ground and grows well on the margins of ponds and on ditch banks, often reaching out to where the water is 3 or 4 feet deep. It is a desirable species for planting on lands liable to overflows, as it is not killed when covered by water for a month or more.

Para grass produces few seeds (usually none in this country) and is generally propagated by divisions of the runners, which root easily when cut into pieces of 2 or 3 joints each and pushed down into freshly plowed ground so as to leave the upper joint at or just below the surface. When sets are abundant, it is better to put them not more than 2 feet apart in each direction, as such close planting enables the grass to cover the ground more quickly and so induces the erect growth more promptly. When wanted for grazing only, close planting is less important and the sets may be placed 4 to 6 feet apart.

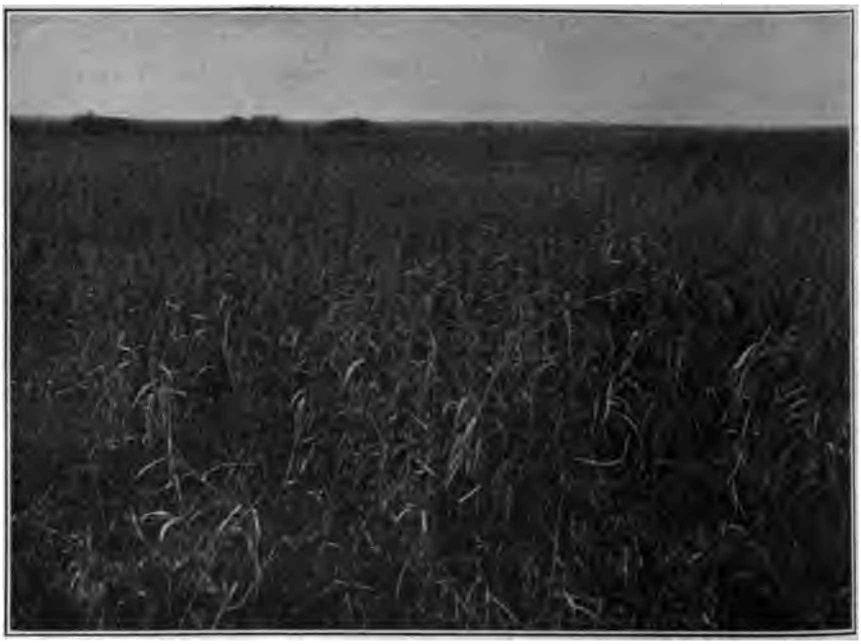


FIG. 5.—Para grass, third year, Kingsville, Tex.

The hay made from Para grass is rather coarse, but is sweet, tender, and nutritious, and the yield is very heavy. One Texas grower reports 6 tons per acre from each of 2 cuttings on a 12-acre field, the second cutting being made in October and followed by excellent winter grazing. Florida growers usually make 3 or 4 cuttings annually, and the hay finds a ready market at the hig price. One grower in southern Florida reports that he makes his first cutting about April 1 and a second cutting about June 1. The ground is then plowed broadcast and harrowed smooth. Two more cuttings are made, in September and November, after which the field gives good grazing until the stock is taken off in March. This is on low ground which is drained by open ditches. The grass makes 2 or more tons of hay at each cutting, and the hay is readily sold to near-by liverymen. Of course such heavy cropping requires liberal fertilizing, but that can well be afforded when a yield of 8 to 10 tons of hay a year is secured, in addition to four months of good grazing. Another grower, in northern Florida, where the grass is more subject to injury by freezing, states that he finds it better to plow the ground in November or December, as the plowing covers portions of the stems, so that they are protected from heavy frosts, and an earlier spring growth is insured.

Para grass is excellent for pasture, is not injured by moderately close grazing or by heavy tramping, and remains green through the entire year, except when cut by frosts. Last year one field of 10 acres in southern Texas gave grazing for 15 cows from April to November, and when the stock was removed the grass was fully 2 feet high and appeared to be growing faster than it was eaten, though the field had not been irrigated during the previous eighteen months. A grower in southern Mississippi reports equally good results from a planting made on low, rich land, and very poor results when planted on high, dry clay. A grower in central Florida states that his field of Para grass gives good grazing for 6 head of cattle per acre at least eight months each year. Another grower, in southern Florida, who has used a few acres of it for pasture a number of years, increased his planting to 100 acres last year, and others in the same section are making similar plantings.

Some orange growers who have Para grass thoroughly established in their groves complain that it makes cultivation troublesome, but as it seldom grows from seed, it is not difficult to hold it in check by the occasional use of a disk harrow. While this grass can be destroyed more easily than some other grasses, it is seldom advisable to plant it in fields which are soon to be used for other crops, but it has great value for making permanent meadows and pastures on wet or even moderately damp soils. As it is killed to the ground by heavy frosts it is not recommended for planting farther north than the northern boundary of Florida, or about latitude 31°.

300

O

INDEX.

Farmers' Bulletin No.

- Acetate, copper, spraying use 284
- Acid phosphate, fertilizer for cotton 286
  - *See also* Sulphuric acid.
- Acidity, soil, green manures, correction by use of lime 278
  - relation to availability of phosphates 296
- Adulteration, alfalfa and grass seed 296
- Air, compressed, use as power for sprayers 284
- Alabama, alfalfa growing experiments 276
- Alcohol, denatured, characteristics 277
  - use in engines in Germany, cost, etc 277
  - engines, exhibitions in European cities 277
    - first use, development, adaptability, and probable future 277
    - mechanism, principles of internal combustion 277
  - ethyl, specific gravities, Smithsonian table 277
  - farm engines, use 277
  - fuel for engines, advantages, summary 277
  - heat value, estimated cost 277
  - tests in gasoline engines 277
  - use in gasoline engines 277
- Alfalfa, composition, fertilizing materials in 100 pounds 278
  - culture, eastern United States 276
  - experiments by eastern State experiment stations 276
  - hay, yield per acre, eastern States 276
  - pasture, cattle and sheep, danger of bloat 276
  - seed adulteration 296
  - seed, quantity per acre 276
  - seed-bed preparation 276
  - silo crop 292
  - soil inoculation methods, comparison 276
    - preparation 280
  - with oats or rye, success in Michigan 280
- Alkali resistance, sorghums 288
- Alligator pear, description, use as food 293
- Ammoniacal copper carbonate, spraying use 284
- Animals, rat destroying 297
- Anthracnose, bean, control 289
  - grape, description, treatment 284
- *Apium graveolens*. *See* Celery.
- Apoplexy, chicken, symptoms, treatment 287
- Apple, bitter-rot, description, cause, control experiments 283
  - blotch, occurrence, destructiveness, description, cause, and control experiments 283
  - digestibility studies 293
  - diseases, spraying in the Ozarks 283
  - leaf-spot diseases, cause and treatment 283
  - orchards, principal enemies 283
  - paring and slicing machines, description, cost 291
  - pomace. *See* Pomace.
  - sauce, digestibility, studies 293
  - scab, description, cause, and treatment 283
- Apples, evaporated, handling, grading, packing, and storing 291
  - prices, 1904–1906 291
  - use of waste 291
  - weight 291

	Farmers' Bulletin No.	Page.
Apples, evaporation	291	1–38
paring, trimming, bleaching, slicing, quartering, etc., for evaporation	291	27–29
ripening, changes in food value	293	20
varieties best suited for evaporation	291	26
Ardmore, Texas, farm, bollworm control experiments	290	21–23
Arkansas apple orchards, apple blotch destructiveness	283	15
demonstration apple spraying, commercial results	283	32
spraying for apple blotch, results	283	17–18
bitter-rot of apples, results	283	10–13
codling moth, results	283	27
Arsenate of lead, spraying grape vines, directions	284	27
shade trees	296	20
use with Bordeaux mixture for codling moth	283	27, 28, 29, 37
Arsenic, poison for rats, directions	297	5
Arsenical poisons, control of bollworm, methods and experiments	290	16–18, 25–27, 31
use against grape-eating insects	284	10, 14, 18, 23, 24, 26
Arsenicals, with or without Bordeaux mixture, apple spraying	283	37
Arsenite of lime, formulas, spraying apple trees and grape vines	283 284	37–38 27
Artichoke, Chinese, names, composition, food value	295	29
Jerusalem, composition, food use	295	28
Automobiles, alcohol fuel, superior to gasoline	277	40
Avocado, description, use as food	293	12
Bacteria, denitrifying, action	278	11
nitrogen-fixing, legumes, discovery	278	8
Bagging grape clusters, protection from injury and disease	284	15, 19, 26, 30
Baits, rat trapping	297	5–6
Bananas, ripening, changes in food value and digestibility	293	21
Bare-lot method of rearing lambs to avoid nodule disease	281	28–29
Barium carbonate, poison for rats, directions	297	4
Barley acreage and production in Columbia Basin, 1899	294	12
feed for laying hens	287	21
yield after red clover	278	16
Barnyard manure. *See* Manure; *also* Fertilizers.		
Barytes, poison for rats, directions	297	4
Batatas edulis. *See* Sweet potatoes.		
Beans, acreage and geographical distribution	289	8–10
breeding for disease-resistance	289	28
classification	289	7
culture and uses	289	1–28
diseases and enemies, control	289	28
field, cleaning and grading	289	17
seed, quantity per acre	289	12
soil preparation, planting, cultivation, harvesting, curing, and thrashing	289	10–18
garden, seed, quantity per acre	289	23
soil preparation, planting, cultivation, harvesting, yield	289	18–25
harvester, description	289	14
industry, divisions	289	10
snap, planting, cultivation, harvesting, and yield	289	18–25
soy. *See* Soy beans.		
thrasher, description	289	16
velvet. *See* Velvet beans.		
See also varietal names.		
BEATTIE, W. R., bulletin on "Celery"	282	1–36
Bedding, cows, sawdust, use and advantages	280	14
Beef scraps, feed for young chicks	287	33
Beet pulp, comparison with apple pomace as feed for dairy cows	280	9
Beetle, flea, grapevine, description, life history, treatment	284	23–24
Beets, canned, food value	295	35
composition, food value, digestibility	295	33, 34–35

	Farmers' Bulletin No.	Page.
Beggarweed, fattening stock	300	8
seed, saving, quantity per acre	300	7
value as forage plant	300	7–8
Bell, G. Arthur, bulletin on "Poultry (chicken) management"	287	1–48
Bermuda grass and white clover mixture for lawn or pasture	281	11
hardy, tests in Oklahoma	281	10–12
hay, analysis, comparison with other grasses	281	12
propagation, preparation of soil	281	12
Birds, bollworm destruction	290	30, 32
usefulness in destruction of rats	297	8
Bishopp, F. C., and C. R. Jones, bulletin on "The Cotton Bollworm"	290	1–32
Bisulphid, carbon, for killing sassafras sprouts	281	16–17
Bitterroot Valley. *See* Columbia Basin.		
Bitter-rot, apple, description, cause, control experiments	283	7–14
grape, description, control	284	36
Black English mulberry, adaptability to Southern States, description	276	6
Black rot, celery, cause and prevention	282	22
grape, description, control	284	29–30
Black scab, apple, occurrence, description, cause and control	283	14–18
Blackberries, analysis, comparison with mulberries	276	8
Blanching celery, methods	282	23–28
Bleachers, fruit evaporation	291	19–22
Bleaching apples, salt solution	293	10
sulphur fumes	291	19–22
potatoes, danger of chemicals	295	18
Blight, celery, cause, prevention	282	21
Bloat, cattle, danger of alfalfa pasture	276	10
sheep, danger of alfalfa pasture	276	10
Blotch, apple, occurrence, description, cause, and control experiments	283	14–18
Blue Mountain region. *See* Columbia Basin.		
Bluegrass seed adulteration	296	8
Bluestem wheat, qualities, advantages	294	25, 30
Bollworm, cotton	290	1–32
annual injury	290	12
cannibalistic destruction of larvæ	290	30
control, field work, 1905–6	290	20–29
general recommendations	290	31–32
methods	290	14–19
natural factors	290	29–31
description, life history, habits, and seasonal history	290	8–12, 17
food plants	290	10
injury, 1903–1906, Texas and Oklahoma	290	12–14
to corn	290	11, 18–19, 25, 28
investigations and experimental work, 1905–6	290	20–29
results	290	7
larvæ on corn, hand picking	290	25, 28–29
various names	290	11
Bone, green cut, feed for laying hens	287	22
young chicks	287	33
Bone meal, hog feeding experiments	276	21–24
Bordeaux mixture, formulas, directions for making	283 284	34–36 38–41
spraying apple for bitter-rot, cost per tree	283	13
blotch	283	17, 18
codling moth	283	27, 28, 29, 30, 37
scab	283	22–23
grapes for fungous diseases	284	30, 32, 33, 35, 36
treatment of bean anthracnose	289	28
use on celery	282	22

	Farmers' Bulletin No.	Page.
Boston brown bread, making, composition, digestibility	298	17, 18, 24
Boykin, E. B., and Herbert J. Webber, bulletin on "Advantage of planting heavy cotton seed"	285	1–16
bulletin on "Value of cotton seed and cottonseed meal in fertilizing cotton"	286	1–14
Brachysticha fidiæ, parasite of the grape rootworm	284	10
Bran, feed for dairy cows, value	280	9
preserving eggs	287	42
Brayton, George, inventor of internal-combustion engine	277	12
Brazos River sediment, annual deposit, estimate	281	8
Bread, white, composition, comparison with potato	295	10
Breads, corn and wheat, average digestibility, comparison	298	25
descriptions, composition, and digestibility	298	17, 24
Breakfast foods, corn, description, food value, and digestibility	298	21, 24, 39
Breeding chickens, number of females to male	287	28
Breeds, chicken, classification	287	5–6
British thermal unit, definition	277	7
Broad beans, locality, uses	289	6
Brodie, D. A., and C. K. McClelland, bulletin on "Diversified farming under the plantation system"	299	1–14
Broilers, rearing and finishing for market	287	34
Brome-grass seed adulteration	296	8
Bronchitis, chicken, symptoms, treatment	287	43
Brooder chicks, rearing, notes	281	27
Brooders, management, notes and suggestions	281 287	27 30–31
Brouhot vaporizer, description	277	31
Brown-rot, grape, description, treatment	284	30–32
Buckwheat feed for laying hens	287	21
Bug, tarnished plant, description, control	282	23
Buildings, dairy, description	280	11–13
rat-proof, use of concrete and wire netting	297	7
Bulbs, succulent, use as food	295	32–41
Bumble foot, chicken, cause, treatment	287	44
Burgundy mixture for spraying grapes, formula	284	30, 40
Cabbages, feed for laying hens	287	23
Cactus, uses as food	293	12
Caladium composition, food use, digestibility	295	30, 31
California citrus orchards, Canada peas as green manure	278	24, 25
Egyptian corn acreage	288	12
experiments with Tangier peas, value on weedy land	278	27
large fruit acreage	298	37
Lima beans, culture	289	26
Calorimeter, measurement of heat of combustion, fuels	277	25–26
Calves, feeding, Kafir-corn mixture	288	24
Camembert cheese, American, making	296	31–32
Canada peas, green-manure use	278	24, 25
Cancer, apple, occurrence, description, cause and control	283	14–18
Canker, apple tree, source of bitter-rot infection	283	9
Canned fruit, 1904, value	293	37
Capons and caponizing	287	35–36
Carbolic acid, use in disinfection of poultry houses	287	42, 45
Carbon bisulphid, killing sassafras sprouts	281	16–17
Carbonate, barium, poison for rats, directions	297	4
Carbonic-acid gas, use as power for sprayers	284	42
Carbureters, various devices, description	277	33–36
Carpocapsa pomonella. *See* Codling moth.		
Carrier, Lyman, bulletin on "A profitable tenant dairy farm"	280	1–16
"Cost of filling silos"	292	1–15
Carrots, composition, description, digestibility	295	33, 36
dried or desiccated, food use	295	37
Cascade Mountain region. *See* Columbia Basin.		
Cassava, bitter, prussic-acid content	295	30
varieties, composition, food use	295	30
Catarrh, chicken, symptoms, treatment	287	43

	Farmers' Bulletin No.	Page.
Caterpillar, celery, control	282	23
CATES, J. S., and W. J. SPILLMAN, bulletin on "Method of eradicating Johnson grass"	279	1-16
Cattle, alfalfa pasture, danger of bloat	276	10
breeding	296	23-25
feed, use of sorghum grain	288	23
grazing, velvet beans	300	10-11
Celeriac, description, composition, and food use	295	33, 35
Celery blanching methods	282	23-28
blight, causes, prevention	282	21-22
botany of plant	282	7
climatic requirements	282	9
cultivation	282	19-20
culture, cost and profit per acre	282	35
diseases, causes, symptoms, and control	282	21-22
fertilizers	282	10-11
growing without irrigation	282	17
harvesting	282	31
heart rot, cause, prevention	282	22
industry, growth, sources of supply	282	8
insect enemies, control	282	22-23
irrigation systems	282	15, 16
marketing, preparation and shipping	282	32-33
mulching	282	18
planting directions	282	17
plants, number per acre	282	17
sanitary conditions, importance of cleanly handling	282	33
seed selection and sowing	282	12-13
soil preparation	282	11
requirements	282	9
storage house, directions	282	30
storing, methods	282	28-31
transplanting	282	14
uses	282	7-8
varieties for home use and market	282	36
watering, different systems	282	14-17
Cement floor, chicken house	287	9
use in rat-proof construction	297	7
Cereal crops, Columbia Basin acreage and production, 1899	294	12
by counties, 1899	294	12
grains, average composition	298	10-11
Cereals, cooking, effects	298	15-16, 28
Cetewayo, food use in Africa	295	23
Chafer, rose. *See* Rose-chafer.		
Charcoal for laying hens	287	25
young chicks	287	33
Cheese, Camembert, American, outline of process	296	31-32
Chemical destruction, Johnson grass, not practical	279	14
Cherry, Surinam, description, use as food	293	13
Chicken digestibility coefficients	276	27
feeding, systems	287	20-22
houses, successful, description	287	12-18
systems, location, and construction	287	6-18
insect pests, treatment	287	47-48
lice and mites, control	287	48
management	287	1-48
raising, making a start, suggestions	287	5
Chickens, bad habits, treatment	287	47
breeding, number of females to male	287	28
classification as to breeds	287	5-6
cleanliness, importance	287	42
diseases, description and treatment	287	43
fattening	287	36-38
healthy, requirements	281	24
incubation, natural and artificial	281	24-28
killing, dressing, and packing for market	287	38-39
raising, requirements for success	287	27-34

	Farmers' Bulletin No.	Page.
Chicks, exercise requirements	287	34
feeding and care	287	31–33
hatching, natural and artificial, directions	281 287	24–28 28–31
incubator, rearing, notes	281	27
number to a hen	287	29
rearing in brooders	287	30–31
with hens	287	29
separating the sexes	287	33
teaching to roost	287	33
Chives, food use	295	41
Cholera, chicken, symptons, treatment	278	44
Chorogi, names, composition, food value	295	29
"Chunno" preparation, food use	295	17
Cibol, food use	295	41
Cider, effect of ripeness of fruit	293	21
Citrus orchards, California, Canada peas as green manure	278	24, 25
Climate, Columbia Basin	294	9–11
Clover, crimson, comparison with nitrate of soda as fertilizer	278	23
composition, fertilizing materials in 100 pounds	278	12
seed, quantity per acre	278	23
value as green manure, effects on succeeding crops	278	22–23
disease-resistant, seed selection	296	9–10
Mexican, description, use, and value for hay and grazing	300	5–7
grazing hogs, cattle, and horses	300	5–6
red, composition, fertilizing materials in 100 pounds	278	12
experiments as green manure, effects on succeeding crops	278	15–16
sweet, seed, quantity per acre	278	24
sod, soil inoculation for alfalfa crop	280	11
value as green manure effects	278	24
white, with Bermuda grass for lawn or pasture	281	11
Coal, heat value, cost	277	7
Coal-tar emulsions, lice killers, comparison with kerosene	276	26
Cocoes, description, composition, food use	295	30, 31
Codfish digestibility coefficients	276	27
Codling moth, apple, injury	283	23
description and life history, number of generations	283	25–27
spraying, in the Ozarks	283	1–42
Coeur d'Alene Mountain region. *See* Columbia Basin.		
Cold storage, evaporated apples	291	38
fruit, temperature, length of time, etc	293	34
preserving eggs	287	42
Colletotrichum trifolii fungus causing clover disease	296	9
Colony plan, chicken houses, description, advantages and disadvantages	287	6–7, 17–18
Colorado River sediment, amount per acre-foot of water	281	8
Columbia Basin, agricultural history	294	11–13
cereal crops, 1899, by counties	294	12
climate	294	9–11
dry farming	294	9–22
soil tillage methods	294	13–22
surface and soils, description	294	7–11
uplands, farm practice	294	1–30
[illegible] measurement by calorimeter	277	25–26
[illegible] internal, of exploding engines, principles	277	18
[illegible] in buildings	280	11–13
[illegible] in rat-proof construction	297	7
[illegible] milk, definition	281	32
[illegible] used	295	41–42
Coniothyrium diplodiella, grape disease, control	284	36
Contagious catarrh, chicken, symptoms, treatment	287	43
Cooker, fireless, or hay box, description, directions for making	296	16–19
Cooking, cereals, effects	298	15–16, 28
fruit effects	293	28–29
[illegible] effects on digestibility	295	13–17
[illegible] evaporators, description	291	7

	Farmers' Bulletin No.	Page.
Cooper, Tex., farm experiments in boll-worm poison control	290	26
Coops, hens with chicks	287	29
Copper acetate, use as nonstaining spray	284	41
ammoniacal solution, use on celery	282	22
carbonate, ammoniacal, use as nonstaining spray	284	41
sulphate solution for Bordeaux mixture, directions for making	283 284	35 39
Copperas treatment of grape anthracnose, iron sulphate solution	284	33
use against weeds, iron sulphate solution	296	10
Coppice management of woodlot	276	30
CORBETT, L. C., bulletin on "Beans"	289	1–28
Corn acreage and production in Columbia Basin, 1899	294	12
value, 1899, comparison with wheat	298	6–7
bollworm larvæ, hand picking	290	25, 28–29
breads digestibility, comparison with wheat breads	298	25
breakfast foods, description, food value and digestibility	298	21, 24, 39
by-products list, uses, average composition	298	7, 13–15
canned, composition, food value	298	35–36
composition and structure	298	8–9
comparison with other cereals	298	10–11
wheat flour	281	19
of sugar corn	298	35
cribs, rat-proof construction	297	7
crop, acreage and value, 1905	281	19
culture, Williamson method	281	13–16
degerminating in grinding, effects on meal and hominy	281	20
destruction by bollworm	290	11, 18–19, 25, 28
dietary value, defects	298	29–31
digestibility coefficients, simple and mixed diet	281	21
Egyptian, acreage, California	288	12
See also Dura.		
feed for laying hens	287	21
feeding value, comparison to sorghum	288	25
fertilizer, use of insoluble phosphates	281	5
Williamson method	281	14, 15
food for man, discussion	281	18–22
importance to early colonists	281	19
uses, various forms	281	18
value	298	1–40
foods, comparative cost as sources of protein and energy	298	32–34
digestibility experiments	298	23–26, 39
preparation, tests of digestibility	281	20
germ, separation in milling, uses	298	12, 14
green, composition, comparison with other vegetables	298	36
food value, uses, composition	298	34–37
grinding, gain in fattening hogs	276	25
history, various uses in different countries	298	5–7
hog feeding, with or without tankage, yield, comparisons	276	22–24
hulled, preparation, composition, food use	298	17, 21, 39
immature ears, pickling	298	36
Jerusalem, names, characteristics, seed, color, and time of ripening	288	8, 9, 10
Kafir. *See* Kafir corn.		
meal, granulated, description of milling process	298	12
hog feeding, with skim milk or tankage, experiments	276	24
nutrients, cost, comparison with other foods	298	32–34
value in diet	298	31
meals, newer types, difference in bread	298	12, 19
milling methods	298	11–12
mixtures for silage	292	11
nutrients, cost, comparison with other foods	298	32–34
parched, composition, food use	298	17, 23
pickles, unripe ears	298	36
pop, composition, food value, uses	298	13, 17, 22

	Farmers' Bulletin No.	Page.
Corn products, average composition, comparison with wheat flour	298	19
composition, comparison with wheat flour	281	13
cooked, composition, comparison with wheat bread, table	298	17
digestibility	281	21
food value	298	1–40
list, uses, average composition	298	7, 13–15
protein deficiencies	298	11, 17, 27, 29
raw, article of diet	298	28
silo, time for cutting	292	11
structure and composition	298	8–9
successive crops, with barnyard manure	280	10
sugar, composition	298	35
trap crop for boll worm, directions, experiments, and results	290	18–19, 27, 31
use in making macaroni	298	18, 23
wholesomeness as food	298	26–28
yield after cowpeas	278	20
crimson clover	278	23
red clover	278	15, 16
Cornstarch manufactured from corn, composition, uses	298	13, 14, 39
Cotton bollworm. *See* Bollworm, cotton.		
cultural methods for bollworm control	290	14–16
early planting and early varieties for control of bollworm	290	15, 21, 22–23
fertilizer, comparative value of cotton seed and cotton-seed meal	286	1–14
fertilizers, use in control of bollworm	290	15, 21–23, 31
growers, disposal of seed to oil mills	286	6
seed and meal, testing for fertilizer value, experiments	286	7
germination tests	285	12, 14
heavy, advantage of planting	285	1–16
Upland, preparation for separation	285	6–8
See also Seed.		
varieties, earliness of maturity, experiments	290	22–23
yield after cowpeas	278	18
soy beans	278	20
velvet beans	278	22
Cotton-seed meal, fertilizer for oats	276	17
value in fertilizing cotton, comparison with cotton seed	286	1–14
Cover crops, orchards, use of legumes	278	13
Cow stable, fireproof, description	280	11–13
Cowpeas, comparison with soy beans	278	20
velvet beans	278	21–22
composition, fertilizing materials in 100 pounds	278	12
economic importance and value	289	7
fertilizing value as green manure, effects on succeeding crops	278	17–19
for corn land	281	14, 16
with and without tubercles, nitrogen yield	278	11
use as trap crop for bollworm, benefit to land	290	19, 31
Cows, dairy. *See* Dairy cows.		
Craponius inæqualis, distribution, life history, habits, and control	284	16–19
Crates, celery, description	282	34, 35
fruit evaporation	291	22
Credit system, tenant farming, injurious effects	299	8
Cribs, corn, rat-proof construction	297	7
Crop bound chicken, symptoms, treatment	287	44
Cropping system, profitable dairy farm	280	9–11
Crops, diversified farming experiments, acreage, tenants, and number of live stock	299	13
rotation after green manures	278	14
Cross-breeding experiments with tomatoes	296	13–14
Crown-gall, grape, treatment	284	37
Cultivation, clean, control of grape root-worm	284	11
Curculio, grape, distribution, life history, habits, and control	284	16–19

Farmers' Bulletin No.

- Curing field beans 289
- Curtain-front chicken house 287
- Cuttings, mulberry, directions for rooting 276

- Daimler carbureter, description 277
- Dairy cows, feeding beggarweed hay and velvet beans 300
    - rations, profitable farm 280
    - soiling, use of Guinea grass 300
        - succotash 276
    - farm buildings, description 280
        - equipment 280
        - labor, division, cost 280
        - manure handling 280
        - profitable, financial statement 280
    - feed, value of beggarweed as hay or silage 300
    - herd, upgrading, directions 296
    - tenant farm, profitable, details 280
- "Damping" celery, cause and prevention 282
- Day, John, Lake. *See* Columbia Basin.
- Degerminating corn in grinding, effects on meal and hominy 281
- Degerminator, use in milling corn 281, 298
- Delaware, alfalfa experiments 276
    - peach growing, decline 276
- Deluge sprinklers for celery 282
- Demonstration spraying, apple diseases, Arkansas 283
- Denatured alcohol. *See* Alcohol, denatured.
- Denitrifying bacteria, action 278
- Desiccated carrots, food use 295
    - fruits. *See* Fruits, evaporated; *also* Fruits, dried.
    - milk, definition 281
    - potatoes, preparation, composition, and food value 295
    - sweet potatoes, food value 295
- *Desmia funeralis*, description, treatment 284
- *Desmodium tortuosum*. *See* Beggarweed.
- Diarrhea, chicken, symptoms, treatment 287
- Diet corn, value, defects 298
    - place of fruit 293
        - potatoes 295
        - sweet potatoes 295
    - simple, low digestibility, comparison with mixed diet 281
    - well balanced, example 298
- Dietary studies, fruits and nuts 293
- Digestibility corn foods, experiments 298
    - in simple and mixed diet 281
    - fish, study 276
    - fruits, study 293
    - poultry, study 276
- Dioscorea, description, composition, food use, and digestibility 295
- Diphtheria, chicken, symptoms, treatment 287
- Dips, lice killers 276
- Disease, bacterial, bollworm destruction 290
    - conveyance by rats 297
    - nodule. *See* Nodule.
- Diseases, apple, spraying in the Ozarks 283
    - celery, causes, symptoms, and control 282
    - chicken, description and treatment 287
    - fungous, of grapes, east of Rocky Mountains 284
    - plant, prevention by soil sterilization 296
- Disking before plowing for summer fallow, advantages 294
- Distillates, petroleum, names, values 277
- Diversified farming, Louisiana, experiment 299
    - under plantation system 299
- Dogs, destruction of rats 297
- Dolichos beans, common names 289

	Farmers' Bulletin No.	Page.
Downy mildew, grape, description and treatment	284	30–32
Drainage, alfalfa, necessity	276	12
Dried carrots, food use	295	37
potatoes, composition, food value	295	17
sweet potatoes, food value	295	27
See also Desiccated.		
Drought resistance, nonsaccharine sorghums	288	12
Dry farming, Columbia Basin	294	9–22
feeding, laying hens	287	20–21
Drying fruit, distinction from evaporation	291	6
See also Evaporation.		
Duck digestibility coefficients	276	27
Dura, acreage, California	288	12
seed, color, time of ripening	288	8, 10
quantity per acre	288	15
sorghums, varieties, names, characteristics	288	8, 9
yields of seed and fodder	288	20
Dust boxes, chicken house, composition, size	287	11
Dusting method, Paris green application to cotton	290	25–27
Early Wilbur wheat, quality, yield	294	25, 30
Eastern United States, alfalfa culture experiments	276	9–14
Eddoes, description, composition, food use	295	30, 31
Egg breeds, chickens	287	5
eating, chicken, treatment	287	47
production, management of hens	287	19–27
yolks, color, effect of feed	287	26
Egg-bound, chicken, cause, treatment	287	46
Eggs, feed for young chicks	287	32, 33
for hatching, number to hen; testing	287	28
preserved in water glass, testing	296	29–31
preserving	287 296	41–42 29–31
selling, methods	287	40
sorting, packing, shipping, and testing for market	287	40
strong germs essential to good hatch	281	14
turning while hatching	281	26
Egyptian corn. *See* Corn, Egyptian; *also* Dura.		
"Elephants' ears," composition, food use, digestibility	295	30, 31
Elevators, silo, types, description, cost of work	292	13
Energy, food, cost in corn	298	32–34
Engines, adaptability of various types	277	10–12
alcohol, first use, development, adaptability, exhibitions in Europe, cost, etc	277	12–15, 37–39
exploding, mechanism, principles of internal combustion	277	15–18
farm, use of alcohol and gasoline	277	1–40
thermal efficiency, relation to cost of fuel	277	8–10
Ethyl alcohol, specific gravities, Smithsonian table	277	24
Evaporated apples. *See* Apples, evaporated.		
fruits. *See* Fruits, dried; *also*, Fruits, evaporated.		
milk, definition	281	32
potatoes, preparation, composition, food value	295	17
sweet potatoes, food value	295	27
Evaporation, apples	291	1–28
fruit, preparation, paring, trimming, bleaching, and slicing	291	27–29
temperature, turning, time for drying, testing	291	30–32
Evaporator appliances, etc., description, use, and cost	291	18–26
cook-stove, description	291	7
Evaporators, cabinet, description	291	17
kiln, description, cost	291	8–15
portable, out-door, description	291	7
tower, description	291	15–16
types, descriptions	291	6–17
Exhibitions alcohol engines, in European cities	277	13

	Farmers' Bulletin No.	Page.
Experiment Station Work XXXIX	276	1–32
XL	281	1–32
XLI	296	1–32
Stations Office, testing alcohol in gasoline engines	277	14
Experimental farms, bollworm investigations, list with location and size	290	20
Exploding engines, mechanism, principles of internal combustion	277	15–18
Explosive mixtures, flame propagation, rate and manner	277	20–22
for use in engines	277	18
limits of proportion	277	19
Exports, fruits, dried, canned and preserved, 1906, value	293	37
Fallowing, summer, reasons for, methods	294	13–21
Farm, dairy. *See* Dairy farm.		
engines, use of alcohol and gasoline	277	1–40
practice in Columbia Basin Uplands	294	1–30
tenant dairy, profitable	280	1–16
woodlot, management, suggestions	276	29–32
Farmers' silos, partnership arrangements	292	15
Farming diversified, Louisiana experiment	299	9–13
under plantation system	299	1–14
hill and river bottom lands, comparison	299	8
single-crop system, permanency, discussion	294	27–29
Farms, experimental, bollworm investigations, list with location and size	290	20
Fattening chickens	287	36–38
crate, chickens, directions	287	36
feed for chickens	287	38
hogs, experiments	276	21–24
ground corn, value	276	25
pigs after cattle	296	21–23
Feather eating, chicken, treatment	287	47
Feed, animal, for young chicks	287	33
fattening, for chickens	287	38
green, for laying hens	287	23
sitting hens	287	29
stock, fodder of nonsaccharine sorghums	288	21
trough, chicken house	287	11, 15, 16
Feeding chicks	287	32–33
dry, laying hens	287	20–21
laying hens, methods	287	25–26
mash, laying hens, formulas	287	21–22
stock, sorghum grain	288	23–25
whole grain, experiments	296	21–23
Fence posts, Russian mulberry	276	7
Ferments, fruit, medicinal value	293	36
Ferrets, destruction of rats	297	6
Fertilizer, commercial, comparison with cowpeas green manure	278	18
grass land, comparison with stable manure	276	18–20
corn, Williamson method	281	14, 15
cotton, comparative value of cotton seed and cotton-seed meal	286	1–14
experiments in bollworm control, yield	290	22, 23
use of acid phosphate and kainit with seed or meal	286	7, 9, 10
Fertilizers, alfalfa	276	13, 14
celery	282	10–11
commercial, use on celery	282	11
cotton, use in bollworm control, notes on ingredients	290	15, 21–24
green manuring comparison with feeding crops	278	12
oats, tests	276	17
peach orchards	276	5
Fertilizing cotton, comparative value of cotton seed and cotton-seed meal	286	1–14
material in 100 pounds various legumes, table	278	12
value of sediment of irrigation water	281	8–10
Fidia viticida. *See* Grape root-worm.		

	Farmers' Bulletin No.	Page.
Fidiobia flavipes, parasite of grape root-worm	284	10
Fireproof barn and stable, dairy farm	280	11-13
Fires caused by rats	297	3
Fish digestibility, study	276	26-27
Flea-beetle, grapevine, description, life history, treatment	284	23-24
Floats. *See* Phosphates, insoluble.		
Floors, chicken house, different materials	287	9
Flour, corn, composition, uses	298	13, 14, 39
paste, use in rolling seed for separation	285	7
wheat, composition, comparison with corn and corn products.	281 298	19 13
Fodder, nonsaccharine sorghums, feeding value and use	288	21
Foliage, injuries by sprays	283	40
Food laws, sulphurous acid in evaporated fruits	291	33
use of corn	281	18-22
fruit	293	1-38
value of corn and corn products	298	1-40
Foods, breakfast, corn, description, food value and digestibility	298	21, 24, 39
corn, digestibility, experiments	298	23-26, 39
other, and fruits, nutrients, comparative cost, table	293	27
Forage plants, Gulf Coast region	300	1-15
Formalin, oats smut prevention	276	17
treatment seed beds	296	13
Fortyfold wheat, description, advantages	294	26, 30
Fountain, drinking, chicken house, care	287	11
Frostbite, chicken, treatment	287	45
Fruit, canned, 1904, value	293	37
bad effect of light	281	22
cooking, effects	293	28
digestibility studies	293	25-26
dried, value, 1904, 1906	293	37
evaporated, curing room	291	32
evaporation, final stage	291	29
preparation, paring, trimming, bleaching, and slicing	291	27-29
temperature, turning, time for drying, testing	291	30-32
evaporators. *See* Evaporators.		
hygienic value	293	35-36
industry, U. S. statistics	293	36-37
jars, varieties, discussion	281	23
marketing and handling	293	32-34
methods of serving	293	21-22
overripe, decayed, and unripe, studies, use	293	30-32
paring and slicing machines, description, cost	291	13, 18, 22
place in diet	293	22-24
ripening, effect on composition	293	20-21
shipping, improved methods, increased supply	293	9
storing, effect on quality	293	34
supply and market conditions	293	9
unripe, most satisfactory for jelly making	293	21
use as food	293	1-38
utilization of poorer grades	291	5
washing, importance to cleanliness	293	33
Fruitarian diet, investigations, notes	293	22-24
Fruit-blotch, apple. *See* Blotch.		
Fruits and fruit products, average composition	293	14-15
other foods, nutrients, comparative cost, table	293	27
canned, preserved, etc., exports and imports 1906	293	37
storing	281	22-24
color and flavor	293	10-11
composition and nutritive value	293	11-19
dietary studies	293	22-24
dried, nutritive value	293	16
evaporated, fluid per cent, standard	291	33
laws, United States, State, and foreign	291	33-34

	Farmers' Bulletin No.	
Fruits, grown in United States in 1899, value	293	
importance in diet	293	
tropical, description, uses as food	293	
wild and cultivated, uses, modifications	293	
Fuel cost per horsepower, tables	277	
fruit evaporation, kind and quantity	291	
vaporization, devices	277	
Fuels, energy, comparative cost	277	
cost, table	277	
farm engines	277	
heat measurement and cost	277	7,
liquid, characteristics	277	
Fumigation, chicken houses with sulphur	287	
Fungi, cause of apple leaf-spot diseases	283	
Fungicides, grape, preparation and use	284	38–41,
Fungous diseases, grape, description, control	284	
east of Rocky Mountains	284	
Fungus, anthracnose, grape, development, injury to grapes	284	
apple scab, development	283	
bitter-rot in apples, development	283	
downy mildew, development, injury to grapes	284	
grape ripe-rot, resemblance to apple bitter-rot	284	
powdery mildew, development, injury to grapes	284	
Furnaces, fruit evaporators, capacity, pipes, etc	291	
Gall, crown, grape, treatment	284	
Gapes, chicken, cause, treatment	287	
Garlic, composition, food use	295	
Gas engines, adaptability	277	
thermal efficiency	277	
heat value, cost	277	
producing plants, thermal efficiency	277	
Gasoline engine and pump for spraying	284	
engines, adaptability, uses	277	
farm engines, use	277	
heat value, cost	277	
Germany, government assistance to development of alcohol engines	277	
practical use of alcohol in farm engines, results	277	
Germination tests, Sea Island cotton seed after separation	285	
Upland cotton seed after separation	285	
Giant tomato, seedless variety	296	
Gila River sediment, amount per acre-foot of water	281	
Ginger root, composition, use as condiment and confection	295	
Glomerella rufomaculans, fungus, cause of bitter-rot in apples	283	
grape ripe-rot, control	284	
Glucose, liquid and solid, manufactured from corn, composition and uses	298	13, 1
potato, manufacture	295	
Gluten feeds, manufacture from corn	298	
Glycine hispida. *See* Soy beans.		
GOULD, H. P., bulletin on "Evaporation of Apples"	291	
Grain feed for chicks	287	
sorghum, food for man and stock	288	
whole, feeding experiments	296	
Grains, cereal, average composition	298	
feed for laying hens	287	
Grape anthracnose, description, treatment	284	
berry moth, distribution, description, life history, and control	284	
bitter-rot, description, control	284	
black-rot, description, control	284	
crown-gall, treatment	284	
cultivation, for control of root-worm	284	
curculio, distribution, life history, habits, and control	284	
diseases, description, control	284	
downy mildew, description, treatment	284	

	Farmers' Bulletin No.	Page.
Grape fungicides, preparation and use, directions	284	38–41, 46–48
fungous diseases, description, control	284	28–30
insect and fungous enemies east of Rocky Mountains	284	1–48
leaf-folder, description, treatment	284	22
leaf-hopper, description, life history, and control	284	19–20
powdery mildew, description, treatment	284	32–33
ripe-rot, description, control	284	35–36
root-rot, causes, prevention	284	37
root-worm, distribution, description, life history, treatment	284	6–12
parasites	284	10
white-rot, description, control	284	36
Grapes, American, resistant to phylloxera, use as grafting stock	284	5
cultivation, use against injurious insects	284	11, 21, 26
infected fruit and leaves, destruction to control fungous diseases	284	32, 35, 37
infested berries and leaves, destruction	284	15, 21, 23
shelling or dropping, causes	284	37
spraying directions and outfits	284	38–48
Grapevine flea-beetle, description, life history, treatment	284	23–24
Grass, Bermuda. *See* Bermuda grass.		
Johnson. *See* Johnson grass.		
land, improvement, experiments	276	18–20
Grasses, Gulf coast region	300	1–15
Grasshoppers, celery, control	282	22
Gray-rot, grape, description, treatment	284	30–32
Grazing cattle, Para grass, value	300	15
hogs and horses, Mexican clover	300	5–6
value of Guinea grass	300	13
Green feed for laying hens	287	23
manure. *See* Manure, green; *also* Legumes.		
manuring, leguminous crops	278	1–27
Grit boxes, chicken house	287	11, 15, 16
for young chicks	287	33
requirements of laying hens	287	24
Group method of managing farm lots	276	32
Gruel, corn meal, preparation	298	20
Guava, uses as food	293	12
Guignardia bidwellii, fungus causing black-rot of grape, control	284	29–30
Guinea grass, description, characteristics	300	11
origin, propagation, use for grazing and soiling	300	11–13
Gulf coast region, some important grasses and forage plants	300	1–15
Gunpowder, ingredients, method of combustion, explosiveness	277	18
Haltica chalybea, description, life history, treatment	284	6–12
Haricot beans, origin, uses	289	6
Harrow, right-lap cutaway, use, description	294	16
Hartman, experiments with alcohol as engine fuel	277	13
Harvester, bean, description	289	14, 16
Harvesters, silage corn, use	292	12
Harvesting beans, string or snap, for market	289	23–25
celery	282	31
field beans	289	14–16
Lima beans	289	27
sorghum for hay or silage	288	17–19
"Hasty pudding," making, use	298	19, 38
Hatching chickens, methods, natural and artificial	281 287	24–28 28–31
Hay, Bermuda grass, analysis, comparison with other grasses	281	12
box or fireless cooker, description, directions for making	296	16–19
clover, feed for laying hens, preparation	287	23
grasses and forage plants for Gulf coast region	300	1–15
Johnson grass grown in rotation with other crops	279	15
nonsaccharine sorghums, value	288	26
Health, hens, droppings as indication	287	22
Heart-rot, celery, cause, prevention	282	22

	Farmers' Bulletin No.	Page.
Heat energy, different fuels, measurement and comparative cost	277	7
Heating apparatus, fruit evaporation	291	23–25
Hedges, Russian mulberry	276	7
Helianthus tuberosus composition, food use	295	28
Heliothis obsoleta. *See* Bollworm, cotton.		
Hellriegel and Wilfarth, discovery of nitrogen-fixing tubercles on legumes	278	8
Hens, age for egg production	287	27
droppings as indication of health	287	26
feeding methods	287	25–26
systems	287	20–22
hatching chicks, directions	287	29
laying, exercise	287	27
management for egg production	287	19–27
molting, care and feed	287	26
setting, directions	281	25
feeding directions	287	29
See also Chickens.		
Hog cots, description, directions for construction, cost, etc	296	27–29
pens, description, directions for construction, cost, etc.	296	27–29
Hogs, alfalfa pasture, value	276	10
fattening, experiments	276	21–24
ground corn, value	276	25
feed, use of Kafir corn	288	24
feeding, ground corn, value	276	25
tankage and bone meal, experiments	276	21–24
grazing, Mexican clover	300	5–6
velvet beans	300	10
soiling, use of succotash	276	20
wallowing vat for killing lice	276	26
Hominy, description, composition, use	298	12, 13, 19, 38
lye, composition, preparation, food use	298	17, 21, 39
Homogenized milk, definition	281	32
Honey vinegar making, directions	276	28–29
Horsepower, measurements in engines	277	8–10
of engines, fuel cost	277	10
Horse-radish, composition, use as condiment	295	41
Horses, feed, Mexican clover	300	6
use of Kafir corn and milo, preparation	288	24
pasture plants, Gulf coast region	300	6, 8, 13
Hose, spraying, requirements	283	39
Hot-bulb vaporizer, description	277	29–30
Humanized milk, description	281	30
HUNTER, BYRON, bulletin on "Farm practice in the Columbia Basin Uplands"	294	1–30
Hyacinth bean, synonyms	289	7
Hygiene of fruit, supposed medicinal properties	293	35–36
Idaho, western, Columbia Basin, cereal crops, 1899	294	12
Ignition temperature, explosive mixtures	277	19
Illinois, alfalfa experiments	276	10
Implements for summer fallowing	294	15–20
Imports, fruits prepared, preserved, and dried, 1906, value	293	37
Incubation, chickens, natural and artificial	281	24–28
Incubator chicks, rearing with hens	281	27
Incubators, hatching chicks	287	30
management	281	26
tests, comparison with setting hens	281	25–26
Indian corn. *See* Corn.		
fig, uses as food	293	12
Territory, cotton bollworm injury, 1903–1906	290	12–14
Indiana, alfalfa experiments	276	10
Inoculation alfalfa soil, methods, comparison	276	13
soil, leguminous crops, methods	278	9
with sweet clover sod for alfalfa crop	280	11

	Farmers Bulletin No.	Page.
Insect enemies, celery, control	282	22–23
grape, description and treatment	284	5–26
east of Rocky Mountains	284	1–48
pests, chicken, treatment	287	47–48
powder, use on broody hens	281	26
Insecticides, grape, directions for application	284	26–28
proprietary, cost, prohibitive	281	18
soluble oils, comparison to lime-sulphur wash	281	17–18
Insects, shade trees, combating	296	19–21
Internal-combustion engine, invention by George Brayton	277	12
engines, mechanism, principles	277	15–18
Ipomœa batata. *See* Sweet potatoes.		
Iron sulphate. *See* Copperas.		
Irrigation, celery, systems	282	15, 16
water sediment, fertilizing value	281	8–10
Jamaica sorrel, use as food, description	293	13
Jams, use in diet	293	24
Jarring, use against grape-eating insects	284	11, 21, 24, 26
Jars, fruit, varieties, discussion	281	23
sealing devices	281	23
Jelly making, notes	293	29
Jenkins wheat, qualities	294	24
Jerusalem artichoke, composition, food use	295	28
corn, names, characteristics, seed, color, and time of ripening	288	8, 9, 10
Johnny cake, description, composition, digestibility, name	298	17, 24, 31
cakes, feed for young chicks, recipe	287	33
Johnson grass, eradication	279	1–16
by careful tillage	279	13
cutting back	279	16
chemical methods not practical	279	14
experiments	279	5
method based on rootstock habits	279	10–12
life history, rootstock habits, types of development	279	6–10
rotations with grain and plowed crops	279	14–15
JONES, C. R., and F. C. BISHOPP, bulletin on "The cotton bollworm"	290	1–32
Fife wheat, description and qualities	294	26
Juices, fruit, food value	293	18
Kafir corn, acreage and production, Kansas and Oklahoma	288	11
feeding hogs	288	24
mixtures for cattle	288	23
seed, color, time of ripening	288	8, 10
quantity per acre	288	15
varieties, names, characteristics	288	8, 9–10
yields of seed and fodder	288	20
Kainit, addition to cotton fertilizer	286	7, 10
Kansas, Kafir corn and milo, acreage and production	288	11
seed law recommendation	296	8
Kerosene emulsion, formulas	276 284	26 28
use against cottony maple scale	296	20
on grape leaf-hopper	284	21
grape vines, preparation	284	28
value as lice killer	276	25–26
engines, adaptability, uses	277	11
heat value, cost	277	7
Kidney beans, origin, uses	289	6
Kiln evaporators, description, cost	291	8–15
King cotton, earliness of maturity experiments	290	23
Kohl-rabi, composition, food use	295	33, 39
Körting Brothers, alcohol engine thermal efficiency, etc	277	13

	Farmers' Bulletin No.	Page.
Labor, dairy farm, division and cost	280	14
silo filling, cost and arrangement	292	6, 9–10
Lake, John Day. *See* Columbia Basin.		
Lambs, nodule disease, bare-lot method of rearing	281	28–29
rearing, bare-lot method, to avoid nodule disease	281	28–29
stomach worms, use of salt	281	29
Land, poor, improvement by rotation, crimson clover and cowpeas	278	23
LANGWORTHY, C. F., bulletin on "Potatoes and other root crops as food"	295	1–45
"Use of fruit as food"	293	1–38
LANTZ, DAVID E., bulletin on "Methods of destroying rats"	297	1–8
Lasius brunneus, var. *alienus*, enemy of grape root-worm	284	10
Late scab, apple, description, cause and control	283	14–18
Law, seed, recommendation for Kansas	296	8
Laws, evaporated fruits, United States, State, and foreign	291	33–34
Lead, arsenate, use on grapevines, directions	284	27
shade trees, directions	296	20
with Bordeaux mixture for codling moth	283	27, 28, 29, 37
Leaf-folder, grape, description, treatment	284	22
Leaf-hopper, grape, description, life history, and control	284	19–22
Leaf-spot, celery, cause, prevention	282	21
diseases, apple, cause and treatment	283	18–20
Leaf-tier, celery, injury, control	282	23
Leathers, fruit, use as food	293	19
Leeks, food use	295	41
Legumes, fertilizer for oats, value	276	17
use of insoluble phosphates	281	6
tubercles, mode of securing nitrogen from air	278	8
Leguminous crops composition	278	11–12
for green manuring	278	1–27
principal, description	278	7, 15–27
Lice, chicken, control	287	48
treatment	281	26, 27
hog, dips for extermination	276	25–26
Lima beans, characteristics	289	6
types, planting, cultivation, harvesting, etc	289	25–27
Limber neck, chicken, symptoms, cause, treatment	287	47
Lime, alfalfa cultivation, use	276	13
and stable manure, effect on crops	281	7–8
arsenite, formulas, spraying apple trees and grapevines	283 284	37–38 27
forms and methods of application, effects	281	7–8
requirements of laying hens	287	24
solution for Bordeaux mixture, directions for making	283 284	35 39
use after green manures	278	14
on celery	282	10
Lime-sulphur wash, comparison with soluble oils for San José scale	281	17–18
Limewater, preserving eggs	287	41
Linters, defective Sea Island cotton	285	15
Listing sorghums, advantages and disadvantages	288	16
Litmus-paper test of acidity of soil	296	6
Little Club wheat, description, yield	294	24, 30
Loquat, use as food, description	293	13
Louisiana, diversified farming experiment	299	9–13
LUCKE, CHARLES EDWARD, and S. M. WOODWARD, bulletin on "Use of alcohol and gasoline in farm engines"	277	1–40
Macaroni, use of corn in manufacture	298	23–26
Machinery, fruit evaporation	291	8, 10–13, 18–22
Maine alfalfa experiments	276	10
Experiment Station, chicken house, description	287	14
Maize, description by Hariot, 1588	298	6
See also Corn.		

	Farmers' Bulletin No.	Page.
Mango, description, use as food	293	13
Manihot aipi, composition, food use	295	30
Manure, barnyard, alfalfa	276	14
comparison with green manure	278	12
corn, successive crops	280	10
fertilizer for oats, value	276	17
use on celery	282	10
green, advantages and objections	278	6–7
choice of crops, points determining	278	14
comparison with barnyard manure	278	12
crops, composition	278	11–12
principal, description	278	7, 15–27
to follow	278	14
fertilizer for oats, value	276	17
object and effect on land	278	5–6
handling, profitable dairy barn	280	14
spreader, use on dairy farm	280	14
stable, grass land, comparison with commercial fertilizer	276	18–20
Manuring, green, leguminous crops	278	1–27
Marketing celery	282	32–33
evaporated apples	291	34–38
poultry and poultry products	287	38–41
Maryland alfalfa experiments	276	11
peach growing, decline	276	5
Mash feeding for laying hens, formulas	287	21–22
Maybach's carbureter, description	277	34
McClelland, C. K., and D. A. **Brodie**, bulletin on "Diversified farming under the plantation system"	299	1–14
Meal, corn. *See* Corn meal.		
cotton-seed. *See* Cotton-seed meal.		
meat feed for laying hens	287	22
"**Mealies**," use of word in South Africa	281	19
See also Corn.		
Meat breeds, chickens	287	6
meal, feed for laying hens	287	22
scraps, feed for laying hens	287	22
Melanconium fuligineum, grape disease, control	284	36
Michigan, alfalfa experiments	276	11
growing, success	280	11
Mildew, downy, grape, description, treatment	284	30–32
powdery, grape, description and treatment	284	32–33
Milk, blended, directions	281	30
carbonated, definition	281	32
certified, definition	281	31
clarified, definition	281	32
condensed, evaporated, definition	281	32
desiccated, definition	281	32
evaporated, definition	281	32
feed for laying hens	287	24
young chicks	287	32, 33
guaranteed, definition	281	31
homogenized, definition	281	32
modified or humanized, description	281	30
pasteurized, definition	281	31
powder, definition	281	32
sanitary, definition	281	31
skim, pigs feeding, comparison with tankage	276	24
standard, definition, requirements	281	29–30
sterilized, definition	281	32
terms, explanations	281	29–32
Millet, German, use as green manure, effects	278	19
Milling corn, methods	298	11–12
Milo, yellow, adaptability to dry regions	288	11
seed characteristics	288	8, 10
various names	288	8

	Farmers' Bulletin No.	Page.
Mississippi, alfalfa experiments	276	11
Missouri, demonstration apple spraying, commercial results	283	33
spraying for codling moth, results	283	28–31
Mites, chicken, control	287	48
Molting, hens, care and feed	287	26
Morus alba tartarica, description, uses	276	7
Moth, codling. *See* Codling moth.		
grape berry, description, life history, and control	284	12–15
Mucuna utilis. *See* Velvet beans.		
Mulberries, analysis, comparison with blackberries	276	8
culture and uses	276	6–9
flavor, appearance, use as food	276	8–9
Mulberry, Black English, adaptability to Southern States, description	276	6
cultivation	276	8
culture and uses	276	6–9
new American, adaptation to Northern States	276	6
propagation	276	7
Russian, description, uses	276	7
varieties, description, adaptability	276	6–7
Mulch dust, celery, maintenance	282	20
Mulching celery	282	18
Mush, corn meal, making, uses	298	19, 38
Mustard, wild, eradication	296	10
Nebraska, apple scab experiments	283	22
Nematodes, disease in seed beds, treatment	296	11
Nests, chicken house, location, size	287	10, 14, 15
New American mulberry, adaptation to Northern States, description	276	6
New Boston, Texas, farm, bollworm control experiments	290	23
"New Hampshire" chicken house, description	287	18
New Jersey, alfalfa experiments	276	11
peach growing, decline	276	5
New York, alfalfa experiments	276	11
large fruit acreage	293	37
Nitrate, soda, comparison with crimson clover as fertilizer	278	23
oats fertilizer, cost and profit per acre	276	17
Nitrogen soil, loss, causes	278	11
sources, cost	278	10
yield, determination, methods	278	10
Nitrogen-fixing bacteria, legumes, discovery	278	8
Nodule disease, infested pastures, treatment	281	28
lambs, control, bare-lot method of rearing	281	28–29
Nonsaccharine sorghums	288	1–28
Nozzle, spraying, requirements	283 284	39 45
Nuts and fruit, dietary studies	293	22–24
place in diet	293	25
Oats, acreage and production in Columbia Basin, 1899	294	12
broadcasting, comparison with furrow planting	276	16
culture in the South	276	14–18
feed for laying hens	287	21
fertilizer tests	276	17
smut, prevention, use of formalin	276	17
sowing, fall and spring, comparison	276	15–16
methods, comparison	276	16
varieties, Southern States	276	15
tests, comparative hardiness and yield	276	15
yield after Canada peas and barley, comparison	278	25
cowpeas	278	19, 20
red clover	278	16
sweet clover	278	24
in rotation with Johnson grass	279	14
Ohio, alfalfa experiments	276	11–12

	Farmers' Bulletin No.	Page.
Oil, corn, manufactured from corn, composition, and uses	298	13, 14, 39
cotton seed, injury by heating of seed	286	13
not valuable as fertilizer	286	5
value annual crop	286	5
waste by use of whole seed as fertilizer	286	6, 9, 10
crude, engines, adaptability, uses	277	11
heat value, cost	277	7
mills, profits, allowance for cotton seed	286	6
Oiling racks of fruit evaporators	291	29
Oils, soluble, comparison with lime-sulphur wash for San Jose scale	281	17–18
Oklahoma, Bermuda grass for lawns or pasture or hay	281	10–12
cotton bollworm injury, 1903–1906	290	12–14
Kafir corn and milo, acreage and production	288	11–12
Olives, mock, pickling unripe plums, directions	296	14–16
pickling directions	296	14–16
Onions, composition, characteristics, food use	295	33, 40
Opuntia spp., uses as food	293	12
Orchard cover crops, use of legumes	278	13
Orchards, citrus, California, Canada peas as green manure	278	24, 25
Oregon, eastern, Columbia Basin, cereal crops, 1899	294	12
Oyster plant. *See* Salsify.		
Oyster-shell lime, value and effects upon land	281	7–8
Ozarks, orchard conditions	283	6
spraying for apple diseases and the codling moth	283	1–42
Ozonium, fungus causing root-rot of grape, prevention	284	37
Package, evaporated apples, description	291	35
Packing eggs for market	287	40
poultry for market	287	39
subsurface, in summer fallow	294	20
Panicum maximum. *See* Guinea grass.		
molle. *See* Para grass.		
Para grass, hay and pasture yield per acre	300	14–15
origin, propagation, uses	300	13–15
Parasites, grape root-worm	284	10
Paring tables and machines, fruit evaporation, description, capacity	291	18–19
Paris green, control of bollworm, methods, quantity per acre, results	290	16–18, 25–27, 31
use on grape vines, directions	284	27
with Bordeaux mixture for codling moth	283	28, 29, 30, 37
Parsnips, composition, food use	295	33, 37
Pasteurized milk, definition	281	31
Pasture, nonsaccharine sorghums, advantages, danger from poisoning	288	22–23
Pastures, value of Para grass	300	15
Pasturing, Johnson grass	279	12, 16
Peach culture, decline in Eastern States, causes	276	5
growing, directions for planting, pruning, and fertilizing	276	5
trees, number in United States, 1890–1900	276	5
Peaches, ripening, changes in fruit	293	20
Peas, Tangier. *See* Tangier peas.		
Canada, green-manure, use	278	24, 25
Pellagra, disease, description, causes	298	28
Pennsylvania, alfalfa experiments	276	12
Pens, hog, description, directions for construction	296	27–29
Petroleum distillates, names, values	277	23
Phaseolus lunatus var. *See* Lima beans.		
multiflorus, description, ornamental value	289	7
vulgaris, origin, uses	289	6
Phosphoric acid, addition to cotton fertilizer	286	7, 9, 10
fertilizer for oats, quantity per acre	276	17
Phosphates availability, in relation to soil acidity	296	6
insoluble, fertilizing value, effects on different crops	281	5–6
necessity of barnyard and green manures	281	6
value for corn and legumes	281	5–6

	Farmers' Bulletin No.	Page.
Phosphoric acid, beneficial effects Texas cotton lands	290	24
Phosphorus, poison for rats, directions, dangers	297	5
Phyllosticta, cause of apple blotch, development	283	15–16
Phylloxera, resistance of American grape varieties	284	5
Picking poultry	287	39
Pigs, fattening after cattle	296	21–23
feeding, skim milk with corn meal, etc., comparison with tankage	276	24
tankage with corn meal, etc., comparison with skim milk	276	24
Pip, chicken, symptoms, treatment	287	44
Piper, C. V., bulletin on "Leguminous crops for green manuring"	278	1–27
Plant diseases, prevention, soil sterilization	296	11–13
Plantation system of diversified farming	299	1–14
Plasmopara viticola, fungus causing downy mildew of grape, control	284	30–32
Plowing, early, with tillage for summer fallow	294	14–16
fall, for control of bollworm	290	15, 31
late, for summer fallow	294	14
shallow, remedy for Johnson grass	279	10–12, 16
Plum, Japan. *See* Loquat.		
Plums, unripe, pickling for mock olives	296	14–16
Poison, grasshoppers on celery	282	22
Poisoning from sorghum pasture, danger, treatment	288	23
rats	297	4–5
Poisons, arsenical, control of bollworm, methods and experiments	290	16–18, 25–27, 31
use against grape-eating insects	284	10, 14, 18, 23, 24, 26
Polenta description, uses	298	20, 23
Polychrosis botrana, distinct from American form of grape berry moth	284	12
viteana, description, life history, and control	284	12–15
Pomace, apple, feed for dairy cows, value, comparison with beet pulp	280	9
storing	280	9
Pop corn, composition, food value, uses	298	13, 17, 22
Potash, addition to cotton fertilizer	286	7, 10
peach orchards, fertilizer	276	5
Potassium phosphate, use in honey vinegar	276	28
sulphate, use in honey vinegar	276	28
Potato crop in diversified farm experiment, net profit	299	10
Japanese, composition, food value	295	29
Zulu, food use in Africa	295	23
Potatoes and other root crops as food	295	1–45
canned, food value	295	18
desiccated or evaporated, composition and food value	295	17
digestibility, experiments	295	21–22
dried, composition, food value	295	17
evaporated, preparation, composition, food value	295	17
history, structure and composition, cooking effects, digestibility, etc	295	7–23
judging for quality	295	20
manufactured products	295	7
nutrients, loss in cooking	295	14–15
nutritive value, comparison with rice	295	13
place in diet	295	22
production and value, 1899	295	7
raw and cooked, composition, comparison with white bread	295	10
storage, effect on quality, favorable temperature	295	18–19
sweet and white, average composition, comparative	295	25
See also Sweet potatoes.		
use in starting yeast	295	17
white and sweet, importance in American diet	295	5
yield after crimson clover	278	23

	Farmers' Bulletin No.	Page.
Poultry, bollworm destruction	290	30
cleanliness, importance	287	42
digestibility, study	276	26–27
feed, use of sorghum grain	288	25
house, rats, poisoning directions	297	5
killing, dressing, and packing	287	38–39
live, shipping	287	39
management	287	1–48
marketing	287	38–41
products, marketing	287	38–41
See also Chickens; Duck.		
Powdery mildew, grape, description, treatment	284	32–33
Power, sources, comparative cost	277	6
spraying apparatus and outfits	283 284	38 41–44
Pox, chicken, poultry, symptoms, treatment, prevention	287	46
Preserves, bad effect of light	281	22
Preserving eggs	287 296	41–42 29–31
Prickly pear, uses as food	293	12
Projaca, description, use	298	18
Propagation, flame cap in explosive mixtures	277	20–22
Protein, corn, difference from wheat protein	298	17, 38
cost in corn foods		32–34
digestibility impaired by excessive use of fats and sugars	281	21
small percentage in tubers and roots, notes	295	6, 11, 28–40
Prussic acid in bitter cassava	295	30
sorghum pasture, cause, antidote	288	23
Pudding, Indian, preparation, composition	298	17, 20
Pump, hand, for spraying	284	41
spray, requirements, different styles	283	38
Pumps for sprayers, requirements	284	45
Pyrethrum, use in emulsion for killing lice	276	26
QUAINTANCE, A. L., and C. L. SHEAR, bulletin on "Insect and fungous enemies of the grape, east of the Rocky Mountains"	284	1–48
W. M. SCOTT, bulletin on "Spraying for apple diseases, etc., in the Ozarks"	283	1–42
Quinlan, Tex., farm, bollworm control experiments	290	26, 27
Racks, evaporator, oiling	291	29
fruit evaporation	291	22
Radishes, composition, food use	295	33, 38
Rat, brown, introduction, life history, habits	291	3–4
Norway, introduction, life history, habits	297	3–4
Rations, dairy cows on profitable farm	280	9
Rat-proof buildings, construction	297	7
Rats, destruction by ferrets and dogs	297	6
methods	297	1–8
disease conveyance	297	3
in poultry houses, poisoning, directions	297	5
natural enemies among birds and mammals	297	8
poisoning, directions	297	4–5
trapping, directions	297	5–6
Red chaff wheat, description, milling qualities	294	24, 30
Russian wheat, qualities	294	26
Retort vaporizer, description	277	28
Rice, nutritive value, comparison with potatoes	295	13
Richardsonia scabra. *See* Clover, Mexican.		
Ripeness, necessity in fruit and vegetables for canning	281	22
Ripe rot, grape, description, control	284	35–36
Rivers, sediment value, estimate	281	8
Roasters, rearing for market	287	34
Rojik, Turkish preparation, food value	293	19
Roller for subsurface packing	294	19

	Farmers' Bulletin No.	Page.
Rolling seed for separation, apparatus	285	6–8
Roof, chicken house, different styles	287	8
Roosts, chicken house, arrangement	287	10, 14, 15, 16
Root crops as food	295	1–45
Root-rot, grape, causes, prevention	284	37
Roots, food, water content, low percentage of protein, notes	295	29–40
succulent, composition, comparison with potatoes, table	295	33
used as food	295	32–41
tropical starch-bearing, food use, composition	295	29–32
used as condiments	295	41–42
Rootstocks, Johnson grass, habits, types of development	279	6–10
Root-worm, grape, distribution, description, life history, treatment	284	6–12
Rose-chafer, description, life history, and treatment	284	24–26
injury to grapes	284	24
Roselle, use as food, description	293	13
Rot, bitter. *See* Bitter-rot.		
black. *See* Black-rot.		
brown, grape, description, treatment	283	30–32
gray, grape, description, treatment	284	30–32
heart, celery, cause, prevention	282	22
ripe, grape, description, control	284	35–36
root, grape, causes, prevention	284	37
white, grape, description, control	284	36
Rotation, crimson clover and cowpeas, for poor lands	278	23
Johnson grass with grain and plowed crops	279	14–15
Roup, chicken, symptoms, treatment	287	43
Russian mulberry, description, uses	276	7
vetch value as green manure, cold localities	278	26
Rye acreage and production in Columbia Basin, 1899	294	12
feed for laying hens	287	21
Salmon digestibility coefficients	276	27
Salsify, black, composition, food use	295	33, 38
composition, food use, varieties	295	33, 38
Spanish, food use	295	38
Salt, lambs stomach worms, use	281	29
preserving eggs	287	42
River sediment, amount to acre-foot of water	281	8
solution for bleaching apples	293	10
use as fertilizer for celery	282	10
Samp, description, composition, use	298	12, 13, 19, 38
San José scale, spraying with soluble oils, comparison with lime-sulphur wash	281	17–18
Sapodilla, use as food, description	293	13
Sassafras sprouts, killing with carbon bisulphid	281	16–17
Sawdust, bedding for cows, value, advantages	280	14
Scab, apple, description, cause, and treatment	283	20–23
Scale, cottony maple, control	296	20
San José, spraying with soluble oils	281	17–18
Scaly legs, chicken, cause, treatment	287	45
Scarlet runner beans, description, ornamental value	289	7
Scheele's green, use in apple spraying	283	37
on grape vines	284	27
Scolymus hispanicus, food use	295	38
Scorzonera hispanica, food use	295	38
SCOTT, W. M., and A. L. QUAINTANCE, bulletin on "Spraying for apple diseases, etc., in the Ozarks"	283	1–42
Sea Island cotton seed, description	285	16
pure and hybrid, distinction	285	16
separation, germination test	285	14–16
Sediment, irrigation, harmful, method of handling	281	9
water, fertilizing value	281	8–10
river, fertilizing constituents	281	8

	Farmers' Bulletin No.	Page.
Seed, alfalfa, adulteration	296	7–9
quantity per acre	276	14
beans, cleaning and grading	289	17
field and garden, quantity per acre	289	13, 23
beds, formalin treatment for disease prevention	296	13
beggarweed, saving, and quantity per acre	300	7
bluegrass, adulteration	296	8
celery, selection	282	12
sowing, early and late crops	282	12–13
clover, crimson, quantity per acre	278	23
sweet, quantity per acre	278	24
cotton, germination tests of different weights	285	12
heating, injury to oil content	286	13
heavy, advantage of planting	285	1–16
improved, use in bollworm control	290	21, 23
preservation	286	13–14
profit to growers by disposing of, in exchange for meal	286	12–13
value annual crop	286	5
in fertilizing cotton, comparison with cotton-seed meal	286	1–14
weight, tests after separation	285	11–14
yield tests before and after separation	285	13
Dura, quantity per acre	288	15
heavy *vs.* light, value	285	5
Kafir corn, color, time of ripening	288	8, 10
quantity per acre	288	15
nonsaccharine sorghums, characteristics	288	8, 10
pure *vs.* poor, comparison of cost per acre	296	7–9
Sea Island cotton, separation	285	14–16
selection for disease-resistant clover	296	9–10
improvement of sorghums	288	27
separated, tests	285	11–14
separation method, description	285	9
Upland cotton, preparation for separation	285	6–8
velvet bean, gathering, and quantity per acre	300	10
Seedless tomatoes, production	296	13
Seeds, cost per acre, standard and poor alfalfa and grass	296	8
Selection, seed, for disease-resistant clover	296	9–10
Separation, cotton seed, method, description	285	9
preparation of Upland seed	285	6–8
Separator, cotton seed, description	285	9–11, 16
Setting hens, directions	281	25
Shade trees, insect enemies, combating	296	19–21
varieties immune from insect pests	296	20
Shallot, food use	295	41
SHEAR, C. L., and A. L. QUAINTANCE, bulletin on "Insect and fungous enemies of the grape east of the Rocky Mountains"	284	1–48
Sheep, alfalfa pasture, danger of bloat	276	10
feed, use of Kafir corn	288	24
[illegible] s, Russian mulberry	276	7
Shipping celery to market	282	33
fruit, improved methods, increased supply	293	9
[illegible] s used	292	11
[illegible]s, size, relation to cost	292	10
sorghums, value	288	23
[illegible] equipment, description, relation to cost of work	292	12–15
filling on 31 farms, equipment, labor, cost per ton, table	292	8
labor, cost, arrangement	292	6, 9–10
methods	292	5–7
Single crop farming, injurious results, discussion	299	7–9
system of farming, permanency, discussion	294	27–29
Skim milk, pigs feeding, comparison with tankage	276	24
Slicing, fruit, machines	291	22
[illegible]icker, for summer tillage, description and use	294	15
Smut, grain, of sorghum, prevention	288	26
[illegible] of sorghum, prevention by seed selection	288	26
[illegible] of formalin	276	18

	Farmers' Bulletin No.	Page.
Soda, nitrate, comparison with crimson clover as fertilizer	278	23
oats, fertilizer, cost and profit per acre	276	17
Sodium phosphate, use in honey vinegar	276	28
Soil acidity, green manures, correction by use of lime	278	14
relation to availability of phosphates	296	6
test, litmus paper	296	6
celery blanching	282	26
requirements	282	9
inoculation, alfalfa, methods, comparison	276	13
leguminous crops, methods	278	9
with sweet clover sod for alfalfa crop	280	11
nitrogen loss, causes	278	11
sources, cost	278	10
preparation for Bermuda grass propagation	281	12
celery	282	11
sorghum	288	14
Soiling crop, succotash	276	20–21
sorghums, value	288	23
value of Guinea grass	300	13
Soils, Columbia Basin, origin and composition	294	11
field beans, adaptability and preparation	289	10–11
sterilization for prevention of plant diseases	296	11–13
Solanin, poison constituent of potatoes	295	19, 20, 44
Solanum tuberosum, food use in Africa	295	23
Sorghum grain, food for man and stock	288	23–25
land preparation	288	14
stubble, plowing under	288	13
yield after cowpeas	278	19, 22
velvet beans	278	22
Sorghums, alkali resistance	288	13
classification and groups	288	7–9
cultivation, harvesting, thrashing, and yields	288	16–20
effect on land, remedy	288	13, 28
fodder and hay, feeding value	288	21
nonsaccharine	288	1–28
diseases and injurious insects, control	288	26
drought resistance	288	12
feeding value, comparison to corn	288	25
improvement by seed selection	288	27
pasture, advantages, and danger from poisoning	288	22–23
sections where valuable	288	11
planting methods	288	16
silage and soiling	288	23
soils, adaptability	288	12
Southern States, oats culture	276	14–18
Soy beans, comparison with cowpeas	278	20
composition, fertilizing materials in 100 pounds	278	12
locality, uses, value	289	7
value as green manure, effects on succeeding crops	278	20
with or without tubercles, nitrogen yield	278	11
Sphaceloma ampelinum, fungus causing grape anthracnose, control	284	34–35
Sphæropsis malorum, found in leaf-spot diseases of apple	283	19
SPILLMAN, W. J., and J. S. CATES, bulletin on "Method of eradicating Johnson grass"	279	1–16
Spray application, directions	283	40
applications, schedule for apple orchards	283	41–42
mixtures, application, directions	284	46–48
Spraying apparatus, description	283 284	38 41–45
apple bitter-rot, demonstration in Arkansas, and results	283	10–13
blotch, demonstration, Arkansas	283	17–18
diseases and codling moth in the Ozarks	283	1–42
orchards in the Ozarks, plan of work	283	7
equipment for apple orchards	283	38–39
materials, apple orchards	283	34-

	Farmers' Bulletin No.	Page.
Spraying preparations, nonstaining	284	40–41
results dependent upon proper preparation and use of sprays	283	5
San Jose scale with soluble oils	281	17–18
times of application	283	7
Sprays, injury to foliage	283	41–42
Spring crops, tillage importance of settling and packing soil	294	21–22
Sprinklers, celery, systems	282	15
Sprout management of wood lot	276	30
Stables, ventilation, experiments	296	25–27
Stachys, composition, food value, names	295	29
sieboldi, names, composition, food use	295	29
Standard milk, definition, requirements	281	29–30
Starch, corn, composition, uses	298	13, 14, 39
potato, manufacture	295	7
sugar. *See* Glucose.		
Starch-bearing roots, tropical, food use, composition	295	29–32
Steam engines, adaptability	277	10
plants, thermal efficiency	277	8–9
sterilization of seed beds	296	13
Sterilization, soils, for prevention of plant diseases	296	11–13
Sterilized milk, definition	281	32
Storage, cold. *See* Cold storage		
potatoes, effect on quality, favorable temperature	295	18–19
sweet potatoes, effect on quality	295	26
Storing canned fruits and vegetables	281	22–24
celery, methods	282	28–31
fruit, effect on quality	293	34
preserves, directions	281	22–24
Stover, nonsaccharine sorghums, feeding value and use	288	21
Straw, wheat, yield after Canada peas	278	25
Strawberries, quantity grown, 1899	293	37
Strychnine, poison for rats, application directions	297	4
Stubble, burning, injury to soil	294	28
cowpeas, effect as green manure	278	18, 20, 21
sorghum, plowing under	288	13
soy beans, effect as green manure	278	18, 20, 21
velvet bean, effect as green manure	278	21
Stubbs mulberry, description	276	7
Subirrigation, celery	282	16
Succotash, mixtures for use as soiling crop	276	20–21
origin, food value, canned, composition	298	35–37
soiling crop, culture, and value	276	20–21
Sugar beans. *See* Lima beans.		
Sugars, fruit, kinds and quantity	293	17
Sujuk, Turkish preparation, food value	293	19
Sulphur flowers, use on powdery mildew	284	33
fruit evaporation, use in bleaching, restrictions, etc	291	19–22, 33–34
fumigation of chicken houses	287	48
[illegible]ves, fruit evaporation	291	22
Sulphuric acid, use on grape anthracnose	284	33
Sulphurous acid, evaporated fruits, laws, United States and foreign	291	33–34
Sweet potatoes, canned and dried, food value	295	27
composition and nutritive value	295	25–27
digestibility and place in diet	295	27
effects of storage and cooking	295	26
evaporated and desiccated, food value	295	27
general uses, stock feed, starch, etc	295	27
origin, varieties, characteristics	295	23–24
yield after crimson clover	278	23
[illegible]		
[illegible]	298	20
Tangier pea, California tests, yield, and value for weedy land	278	27
value as green manure and hay	278	27

Farmers' Bulletin No.

- Taniers, description, composition, food use ... 295
- Tank outfits for orchard spraying ... 283
  - vineyard spraying ... 284
- Tankage, hog-feeding experiments ... 276
- Tarnished plant bug, description, control ... 282
- Taro, varieties, composition, food use and digestibility ... 295
- Taye, description, composition, food use ... 295
- Tenant dairy farm, profitable, details ... 280
  - farming, credit system, injurious effects ... 299
- Testing eggs for hatching ... 287
  - market ... 287
  - preserved in water-glass ... 296
- Tests, separated cotton seed, germination and weight ... 285
- Texas, cotton bollworm injury, 1903–1906 ... 290
  - crop, 1903–1906 ... 290
  - Kafir corn and milo acreage and production ... 288
  - soils, need of fertilizers, notes ... 290
- Thermal efficiency of engines, relation to cost of fuel ... 277
  - units, measurements, cost, different fuels ... 277
- Thinning timber in woodlot, directions ... 276
- Thrashing beans, description of machine ... 289
  - sorghum ... 288
- Tier, leaf celery, injury and control ... 282
- Tiles, drain, celery blanching ... 282
- Timber, thinning in woodlot, directions ... 276
- Tobacco lands, Connecticut, hairy vetch as cover crop ... 278
- Tomatoes, seedless, production ... 296
- Tower evaporators, description ... 291
- Townsend mulberry, description ... 276
- TRACY, S. M., bulletin on "Some important grasses and forage plants for the Gulf Coast region" ... 300
- *Tragopogon porrifolius*, food use ... 295
- Transplanting celery ... 282
- Trap crops for control of bollworm, methods, experiments, and results ... 290
- Trapping rats, directions ... 297
- Traps, rat, description, directions for baiting ... 297
- Trays, fruit evaporation ... 291
- Trees, shade, insect enemies, combating ... 296
- Trenching celery, directions ... 282
- Tropical starch-bearing roots, food use, composition ... 295
- Tubercles, legumes, mode of securing nitrogen from air ... 278
- Tubers, food, water content, low percentage of protein ... 295
  - succulent, used as food ... 295
- Turkey Red wheat description, advantages and disadvantages ... 294
- Turnips, composition, food use ... 295
- *Typhlocyba comes*, description, life history and control ... 284

- *Uncinula necator*, fungus causing powdery mildew of grape, control ... 284
- Unripe fruit, digestibility studies ... 293
- Uplands, Columbia Basin, farm practice ... 294

- Vaporizers, various devices, description ... 277
- Vegetables, canned, storing ... 281
  - composition, comparison with green corn ... 298
  - feed for laying hens ... 287
- Velvet beans, composition, fertilizing materials in 100 pounds ... 278
  - cultivation and yield ... 300
  - green manure for corn land ... 281
  - locality, uses ... 289
  - seed, gathering, quantity per acre ... 300
  - value for forage and rotation crop ... 300
    - grazing hogs and cattle ... 300
    - green manure, comparison with cowpeas ... 278

	Farmers' Bulletin No.	Page.
Ventilation, chicken house	287	11, 13, 14
stable, experiments	296	25–27
Venturia inæqualis, cause of apple scab	283	21
Verjuice, description, use as condiment	293	19
Vermont, alfalfa experiments	276	12
Vertigo, chicken, symptoms, treatment	287	43
Vetch, common, value as green manure, objections	278	26
composition, fertilizing material in 100 pounds	278	12
hairy, cover crop for Connecticut tobacco lands	278	26
value as green manure, cold localities	278	26
Russian, value as green manure, cold localities	278	26
Vibrissea hypogæa, fungus causing root rot of grape, prevention	284	37
Vicia faba, locality and uses	289	6
Vigna sinensis. *See* Cowpeas.		
Vinegar, honey, making, directions	276	28–29
sources, use and value as food	293	19
Vineyard cultivation for control of injurious insects	284	11, 21, 26
spraying, directions and outfits	284	38–48
See also Grapes.		
Virginia, alfalfa experiments	276	13
Vitis vinifera, susceptibility to attacks of phylloxera	284	5
Wagons, silage hauling	292	12–13
Walla Walla Valley. *See* Columbia Basin.		
Walls, chicken house, foundation and sides	287	8, 10, 15, 17
WARBURTON, C. W., bulletin on "The nonsaccharine sorghums"	288	1–28
Washington, eastern, Columbia Basin, cereal crops, 1899	294	12
wheat, average yield, 1906	294	29
Wasps, bollworm destruction	29	30, 32
Waste, evaporated apples, use	291	32
Water, absorption by cereals	298	16
irrigation, sediment, fertilizing value	281	8–10
pipes, lead, injury by rats	297	3
pure, supply, care of wells	296	5
requirements, celery, methods of applying	282	14–17
of laying hens	287	24
supply for mixing Bordeaux mixture	283	36
Water-glass, preserving eggs, testing	287 296	41 29–31
Watermelon crop, in diversified farm experiments, net profit	299	10
WEBBER, HERBERT J., and E. B. BOYKIN, bulletin on "Advantage of planting heavy cotton seed"	285	1–16
Weeds eradication with iron sulphate (copperas) solution	296	10
Weevil, bean, destructiveness in southern latitudes	289	28
Wells, construction and protection to insure pure water supply	296	5
Whale-oil soap, use on grape-vines, directions	284	21, 28
Wheat acreage and production in Columbia Basin, 1899	294	12
bearded, horse feed, injurious effects	294	27
digestibility, comparison with corn products	281 298	21 25
breads, advantages over corn breads	298	17, 40
crop, acreage and value, 1905	281	19
feed for laying hens	287	21
flour composition, comparison with corn products	281	19
varieties grown, Columbia Basin	294	22–27, 30
yield after buckwheat	278	25
Canada peas	278	25
cowpeas	278	18
[illegible]	278	25
[illegible] ion of crimson clover and cowpeas	278	23
velvet beans	278	21
See varietal names.		
Wheat, spring varieties, Columbia Basin, description	294	23–25, 30
winter varieties, Columbia Basin, description	294	25–27, 30

LIBRARY OF CONGRESS
0 002 892 726 5